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electronics

radio, communication, industrial applications of electron tubes . . . engineering and manufacture

Award, Radio Club of America
Armstrong Medal to Alan Hazeltine

DECEMBER
1937

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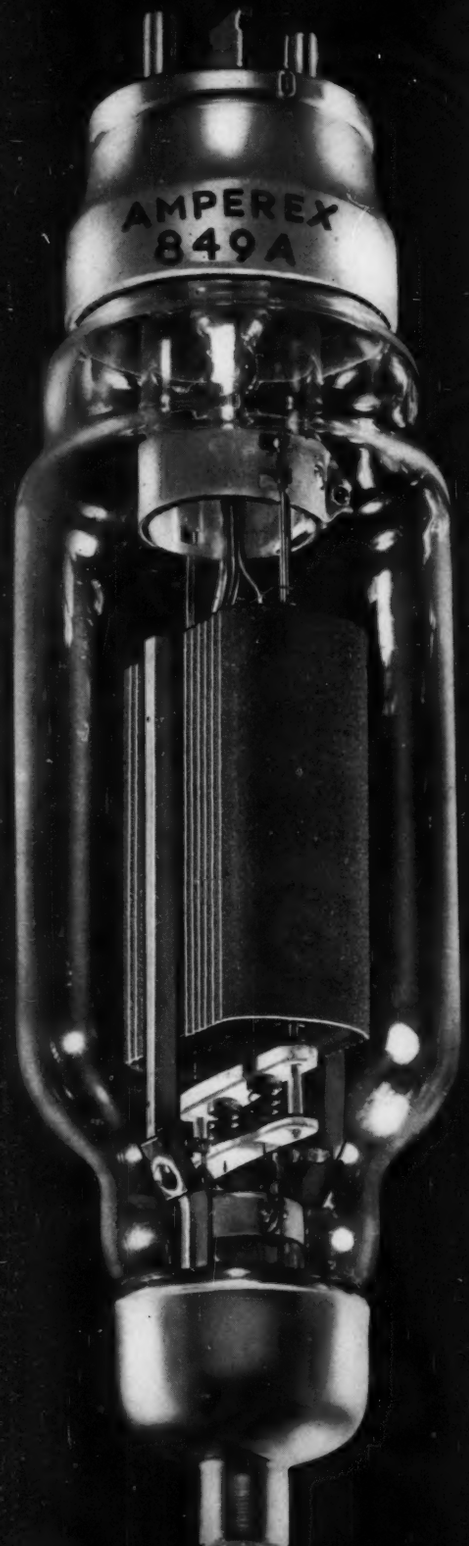

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AMPEREX 849A
and AMPEREX *849H

Greater Power Output
Higher Plate Dissipation
Longer Operating Life
*Higher Ratings at High Frequency

The application by Amperex of the modern engineering concept of the space relationship of electrodes in a vacuum tube has resulted in the design of a new type with far greater performance capabilities than the standard 849. Simplification of structure because of this new design has also made possible considerable economies in manufacturing processes which are reflected in the price of these tubes.

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The features enumerated above clearly demonstrate that not only can these tubes be used profitably to replace 849's in existing equipment but that they also fill a gap in the air cooled line of tubes for use in equipment where severe derating at high frequencies forced the use of much larger and costlier tubes.

*** The 849H can be operated at full ratings up to 30 megacycles in many classes of service. It is identical in its characteristics with the 849A. The only point of difference is the grid lead terminal which in the 849H terminates in an arm extending from the side of the bulb.**

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AMPEREX ELECTRONIC PRODUCTS, Inc.

ELECTRONICS

DECEMBER
1937

KEITH HENNEY
Editor

Crosstalk

▶**MEDAL** . . . Late in October, Radio Club of America (founded in 1909) awarded its first Armstrong medal to Professor Alan Hazeltine of Stevens. Thus the medal, established to honor the achievements of Edwin H. Armstrong now Professor of Electrical Engineering at Columbia but better known for regeneration, superheterodyne, super-regenerative and frequency modulation contributions goes to a professor of physical mathematics, well known in his own right as a contributor to the art and science of radio communication.

Not only did Professor Hazeltine make possible the first stable broadcast receiver, but he contributed the term "mutual conductance" and much mathematics to the literature. Both of these men made most of their important disclosures before the Radio Club of America. Thus the award was most appropriately and happily made.

John H. Miller, assistant chief engineer of Weston Electrical Instrument Company made the presentation. Harry Sadenwater, radio officer on the NC-4 acted as toastmaster of the dinner.

In justice to Professor Hazeltine and Mr. Miller it might be said that their apparent heavenward glances shown on the front cover were due to the fact that they were instructed to look at one camera (a professional) while Arthur Van Dyck made the cover shot with another—using the professional's flash! Mr. Miller, particularly, does not wish to appear so sanctimonious.

▶**BLATANT** . . . British engineers are somewhat amused and annoyed by boasting statements of American radio officialdom who return to this country announcing that the British television system is only a copy of American practice and that the Britishers have made little or no contributions to our art. (See *Wireless World*, p. 431, October 29.) American engineers, however, after a trip abroad admit that very definite contributions have been made by the English engineers who have been forced to carry commercialization and research along hand in hand. One of the contributions seems to be television pick-up tubes with considerably greater sensitivity than those used here at present.

Any reader who was not in Europe during the summer of 1937 to study English and German television methods can qualify as member of a very exclusive group, the "did-not-go-to-Europe-club."

▶**FACSIMILE** . . . Most hopeful is the operation by several broadcast stations of experimental facsimile transmitters during the hours the broadcast programs are off the air. WOR and WQXR in New York, several stations in the west and middle west are numbered among this group which has not lost sight of the potential service offered by facsimile apparatus already developed but long looking for a market.

▶**OUR ERROR** . . . *Electronics* has not been immune to an error which seems to be rather common in this country. This is calling the BBC the British Broadcasting Company when it is really the British Broadcasting Corporation. A reader in British Columbia takes us to task for this error, committed more than once in these pages, and points out the additional fact that the BBC is not supported by government subsidy (page 32, October). Far from being supported, some of the money collected by license fees from listeners gets into the government treasury, whence it never gets free for broadcasting purposes. Thus it is even more remarkable, according to our critical reader, that the BBC can furnish such a fine public service with the funds available, almost infinitesimal compared to those involved in the "fundamentally wasteful American system of commercial broadcasting."

▶**P.S.** . . . In the article "Television in Great Britain" (October, 1937) the transmission from Alexandra Palace was referred to as the BBC system. It is our understanding that the transmitter in use at Alexandra Palace is that designed and built by the Marconi-EMI Company and selected by the BBC after months of comparison tests with an alternative system. It should therefore be referred to as the Marconi-EMI system.

▶**454 TUBES** . . . As this issue goes to press the editors have had the pleasure of listening to Captain Richard Ranger's new electronic organ. Runner-up to the Broadway sign (*Electronics*, September 1937) for large number of tubes in use, the new Rangertone uses one tube for each key and for every tonal quality available to the organist. Present instrument has tubes for 7 octaves times 12 notes times 4 keyboards plus power supply plus power amplifiers—100 watts to the speakers.

▶**SWEET VOICES** . . . The Japanese "Den Kino-Tomo" laments the fact that automatic telephone exchanges have eliminated the sweet human voices that used to announce "number, please" and "the line is busy", however they say it in Japanese.

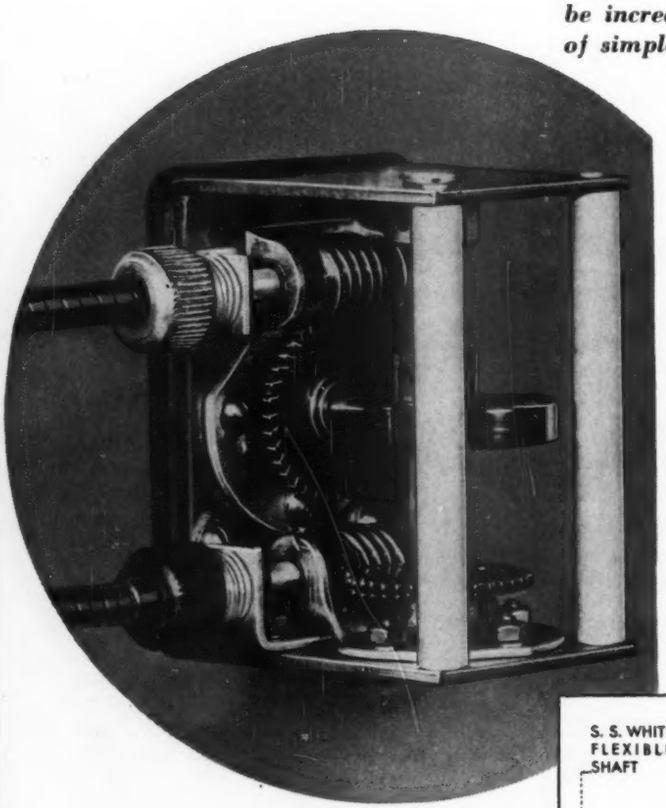
So great has been this loss to the service, that a method of superseding mechanical sounds and dry clicks with the voice again is being worked out by the use of phototubes, etc. It will cost 500 yen to build and "hallo girls with sweetest voices are engaged in recording sound films and when the apparatus are adopted country-wide we may again hear the sweet answers which were ours in the good old times."

Engineers, with your efficiency, be damned!

MEMO for Designing Engineers

Gearing possibilities greatly enlarge the scope of Flexible Shafts....

When considering flexible shafts for transmitting power, it should be borne in mind that the *normal torque capacity* of any particular size of shaft *can be increased to any reasonable amount by the use of simple gearing.*



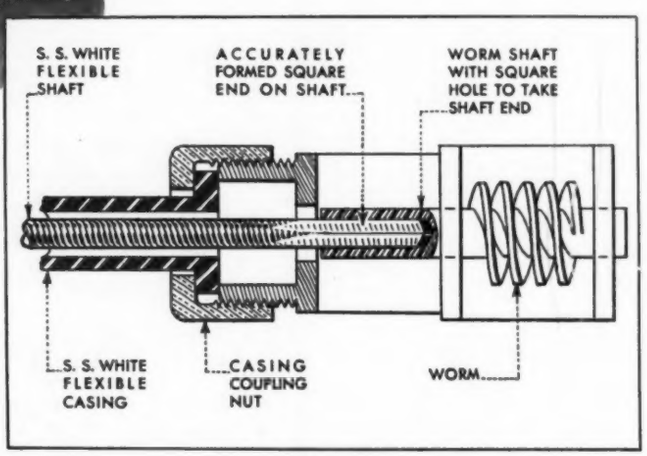
And where *accurate synchronism* between driving and driven members is essential, it can also be secured in the same way.

In the case of a remote control, any desired degree of sensitivity can be provided by using gearing at one or both ends of the shaft.

The typical geared assembly shown in the illustration, makes clear how readily flexible shafts can be applied to gearing.

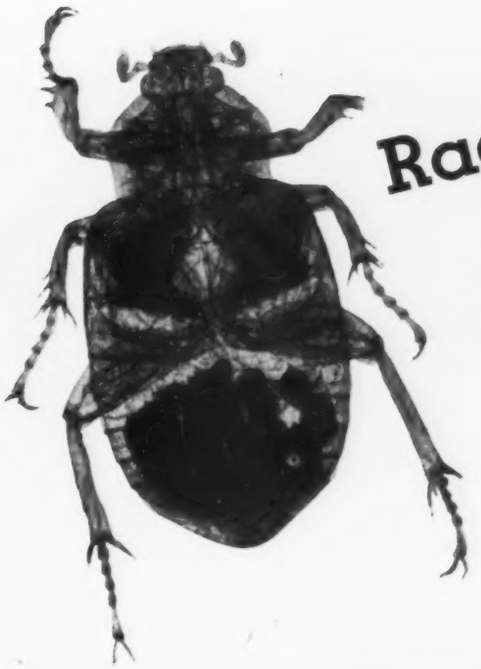
If you have a power drive or remote control problem, our engineers will be glad to submit recommendations. There is no obligation. Just send us essential data.

Drawing at the right shows how the flexible shafts and their casings are attached in this application. This is but one of the innumerable combinations of shafts and gearing that are possible.


S. S. WHITE FLEXIBLE SHAFT
ACCURATELY FORMED SQUARE END ON SHAFT
WORM SHAFT WITH SQUARE HOLE TO TAKE SHAFT END
S. S. WHITE FLEXIBLE CASING
CASING COUPLING NUT
WORM

The S. S. WHITE Dental Mfg. Co.
INDUSTRIAL DIVISION
10 East 40th St., Room 2310E, New York, N. Y.

Soft X-Ray Radiography



Flower hermit beetle, x 5

An extension of the application of X-rays is the use of radiations produced by electrons moving at speeds corresponding to 4 to 18 kilovolts. The beautiful examples of radiography shown here give evidence of the utility of these medium speed electrons

By H. F. SHERWOOD

Research Laboratories
Eastman Kodak Co.
Rochester, N. Y.

FOR many years after Roentgen's discovery of X-rays, their practical application was confined almost entirely to the field of medicine, i.e., in the examination of internal structures of the human body. Gradual improvement in X-ray apparatus, however, has greatly extended the usefulness of X-rays, particularly in the inspection of a wide variety of industrial materials. One type of this radiation, soft X-rays, have the penetrating power which is especially suited to the radiography of small industrial and biological specimens, such as cloth, leather, paper, portions of plants, insects, etc. This article will deal primarily with the accomplishments of soft X-ray radiography.

X-rays are produced in a special form of electronic tube, in which high-speed cathode rays are focused on a small area of the plate or target. The X-rays are generated by the impact of the electrons upon the target, and the penetrating power of the rays increases with the voltage applied to the X-ray tube. The soft X-rays under discussion are produced in the range 4 to 18 kilovolts, medical X-rays in the range 40 to 100 kilovolts, while X-rays for the radiography of several inches of steel may require 200 kilovolts or more. The target of an X-ray tube generally consists of tungsten, because of its efficiency in the production of X-rays and its ability to withstand the heating effects of cathode-ray bombardment.

A soft X-ray tube must be fitted with a window sufficiently thin to permit the emergence of the X-rays, and the most satisfactory form is the Slack window consisting of an indrawn bubble of glass measuring approximately 15 microns in thickness. On page 10 is a diagram of such a tube, and the arrangement for radiography wherein the X-rays are directed through the specimen onto the photographic plate or film.

The range of exposure conditions commonly used in soft X-ray radiography is indicated in the following table:

TABLE I

Tube Voltage	4 to 18 K.v.P.
Milliamperes	1 to 8 ma.
Anode film distance	2 in. to 15 in.
Exposure times	3 sec. to 3 min.

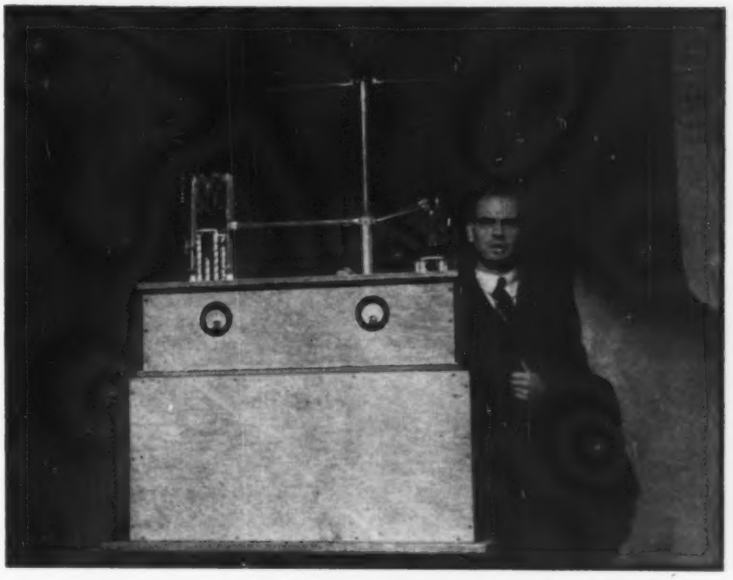
In the radiography of cloth, soft X-rays show the presence of metallic weighting, defects in the weave and, when used stereoscopically, make it possible to visualize clearly the paths of the threads in the weave, both through the depth of the cloth, and in its lateral extent.

Soft X-ray photograph (reversed in tone) of columbine showing beautiful detail in buds, blossoms and seed pods

Rochester, 1937

Most successful Rochester I.R.E.-R.M.A. Fall Meeting draws record attendance to hear papers on television, new modulation systems, inverse feedback, and "teledynamic control", remote control of radio sets via the power line

BUSINESS recession notwithstanding, the attendance at the 1937 Rochester Fall Meeting on November 8, 9, and 10 broke all previous records, with a registration of 513 and a total attendance estimated at nearly 600. This enthusiastic response was in part a reflection of the growing popularity of the Rochester meetings, and in part due to the highly attractive program arranged by the Committee.



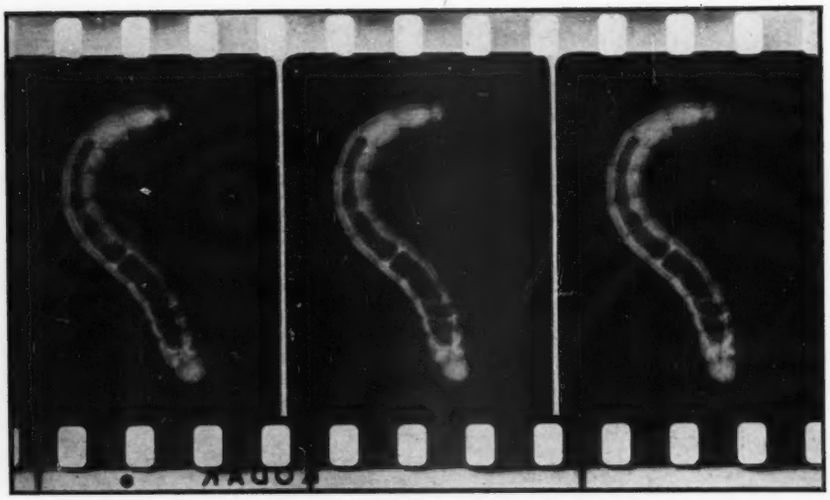
William N. Parker of Philco with his 200-megacycle transmitter, capable of modulation with side-bands 20 megacycles wide. Quarter-wave resonant line sections (to right of base of antenna transmission line) are terminated in modulator tubes, as shown in the diagram on page 14

Television Papers Predominate

Of the nineteen papers on the program, ten were directly or indirectly concerned with television development, and these were presented by engineers of four different companies. Both in variety and in difference of viewpoint these papers constituted a "television symposium" of wide interest.

The first paper was by C. E. Burnett, RCA Radiotron, "The Monoscope", a television signal-generating tube resembling the Iconoscope in general principle but differing in that the signal is derived from the variation in secondary-emission current from a single picture or pattern enclosed in the tube. The tube is not in any sense a pick-up tube, since it cannot convey a moving image and since it does not depend upon photoelectric emission, for the formation of the signal. A typical form of Monoscope is constructed as follows: in the evacuated tube is placed a flat plate of aluminum foil, some 0.004" thick, on which is printed, with ordinary foil-ink commonly used by printers for the purpose, an image, the printing being in the form of a half-tone or a simple black-and-white character. In the processing of the tube the plate is fired in hydrogen which removes the volatile oils from the ink and leaves practically pure carbon. The tube contains an electron gun whose beam scans the signal plate in the same manner as in the Iconoscope. When the beam hits a portion of the plate on which no ink is present, it excites emission of secondary electrons from the aluminum or from the coating of aluminum oxide on its surface. On the other hand, when the beam hits the printed portion secondary electrons are released from the carbon layer but not as freely as from the aluminum. The difference in secondary electrons emitted by carbon and aluminum constitutes a change in electron current flowing from the signal plate, and this current change may be used to develop a video signal voltage across the external coupling resistor. A conductive coating is provided inside the tube to collect the secondary electrons, which are eventually returned to the signal plate. The printing of the plate is accomplished from conventional 133 line-per-inch half-tone engravings or from zinc line-cuts. In the case of half-tones the size of the plate is such that about 450 dots are contained in the vertical direction within the picture, which is somewhat in excess of the number of lines used to scan the plate.

The signal developed by the tube varies with beam current, but under typical operating conditions it delivers about 3 or 4 millivolts across a 10,000-ohm load. The use of the tube is primarily in testing video equipment. Since it provides a stable signal of large amplitude and of very crisp quality it is better suited to testing than is the Iconoscope. The video signal provided by the Monoscope is so rich in the high harmonics (which represent the fine detail of the image) that it can be used to test transient response of

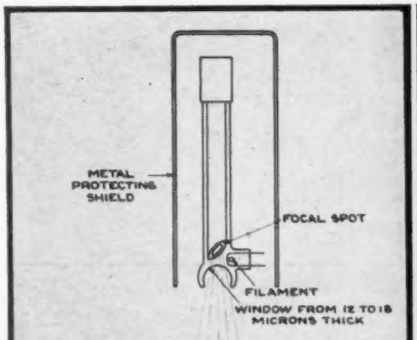


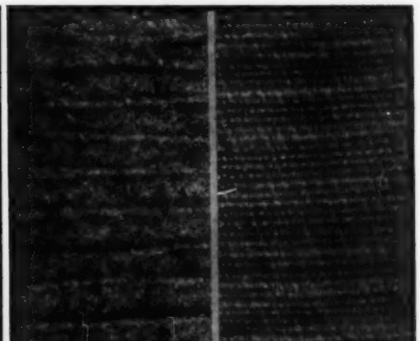
35 mm motion picture of yellow meal worm. Right—maple leaf

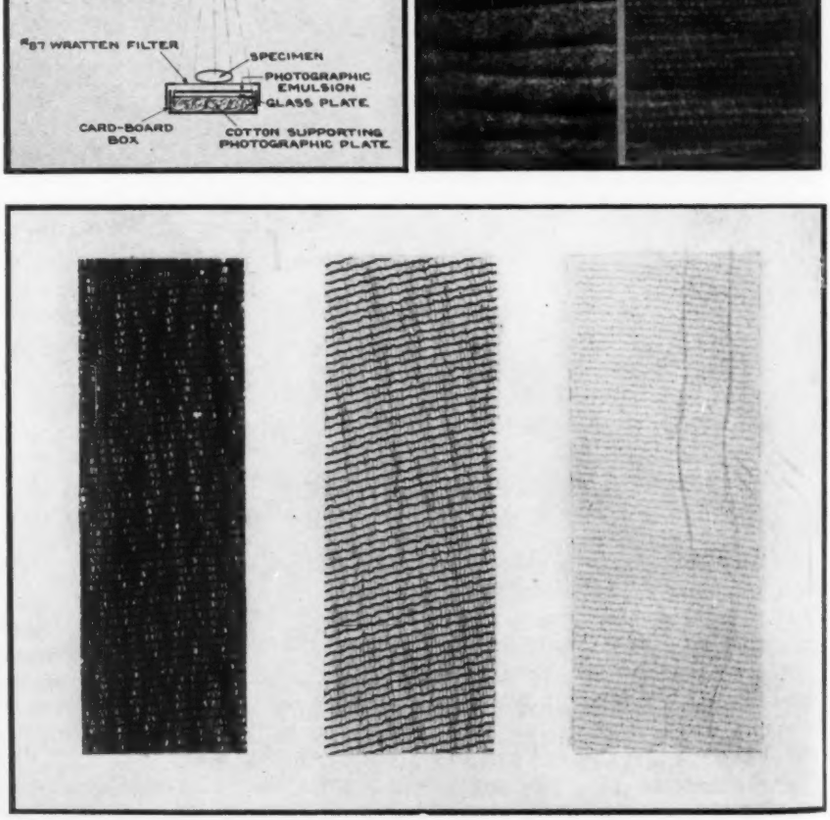
Stereoscopic radiographs of small objects are made by exposing two separate radiographs with two beams of X-rays spaced ten degrees apart, with the specimen held in a fixed position. These radiographs may be enlarged and viewed in an ordinary stereoscope, or they may be examined under a special stereo-microscope which affords sufficient magnification to show the finer details of the image.

The most recent application of soft X-rays is in recording the internal movements of small biological specimens in the form of motion pictures. The motion picture film of 35-mm. width, coated with photographic emulsion especially designed for soft X-ray radiography, is loaded in a standard form of motion picture camera, with lens removed, and with an infra-red gelatin filter covering the gate to protect the film from light. This filter also serves to support the specimen radiographed. Such motion pictures have been made at the rate of 16 frames per second, using a meal worm as a subject. These films show clearly the peristaltic movements of the intestinal tract, both with the worm in normal condition and under gaseous anesthesia.

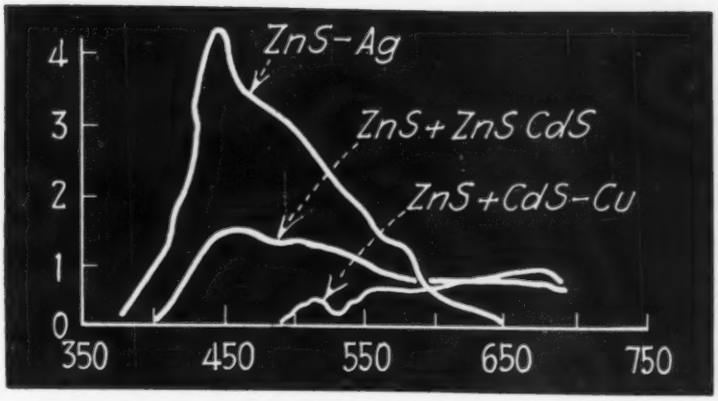
The experience gained thus far with the method of soft X-ray radiography indicates clearly its value both for teaching and research purposes, in the examination of small biological specimens, and shows promise of valuable applications in the inspection of appropriate forms of industrial materials.



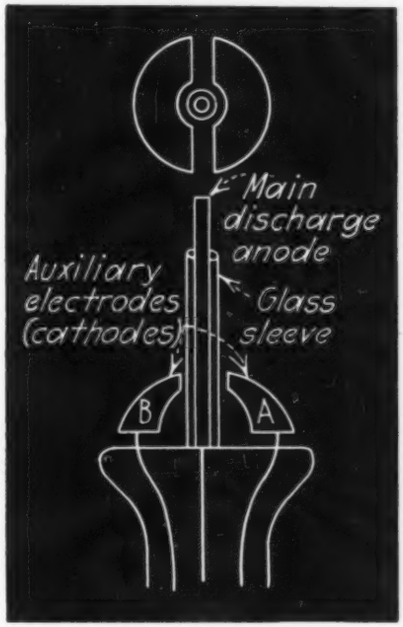




Above—Position of subject, X-ray tube, holder. Radiographs of genuine and imitation leather. Below—Weighted silks x 5. Lead, 40 per cent by weight, tin, 28 per cent by weight, and pure silk, no weighting

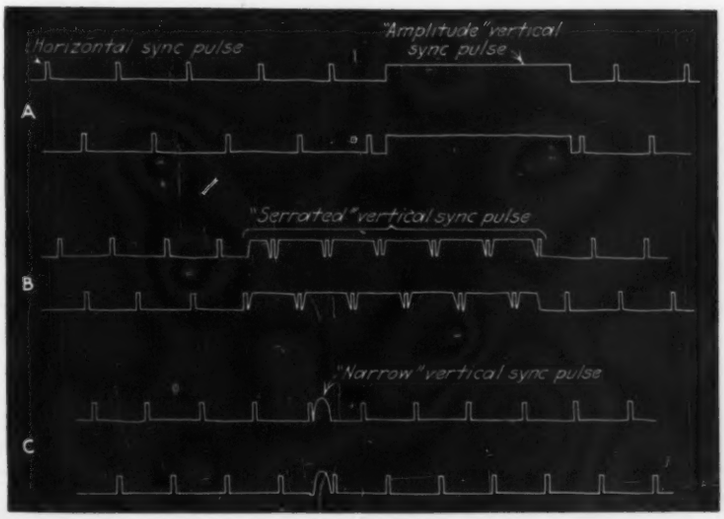


Color analysis diagrams of fluorophor cathode-ray screen materials. The scale is in millimicrons (visible limits 400 to 700). Zinc sulphide with zinc-cadmium sulphide gives a white light, but is not as bright as the silver-activated zinc sulphide



Element structure of the gas-filled cold-cathode tube used in the teledynamic control of radio receivers (see diagram on page 14)

Several forms of signal pulses used for synchronizing the lines and frames of television images, discussed by F. J. Bingley



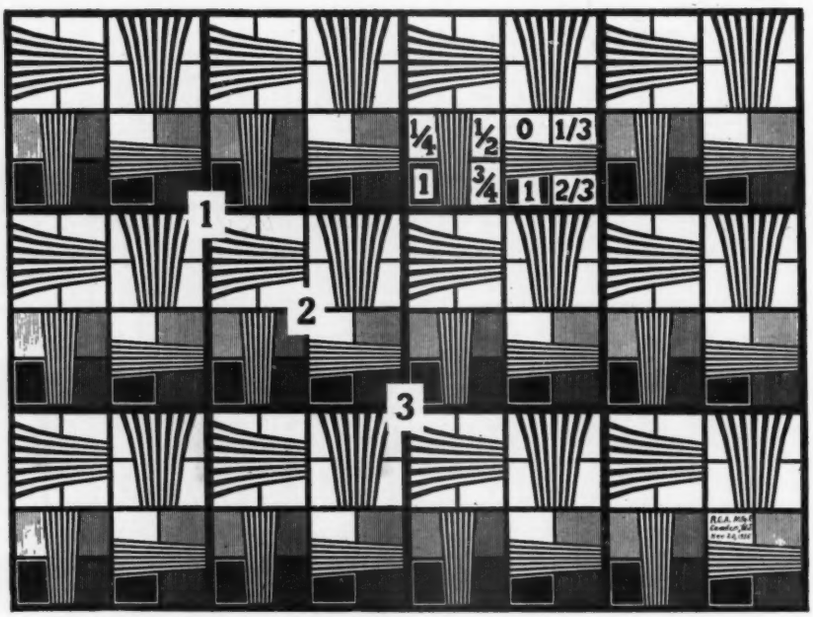
produced, and this color may be superimposed on the light from the cathode-ray screen for comparison purposes. In terms of the known characteristics of the filters used, the spectral composition of the fluorescent light may be determined. A third method, the use of a self-generating photoelectric cell and filters of known characteristic, was investigated and found to be less reliable than the other two. Several spectral composition curves of screen materials taken by the authors are shown in the accompanying illustration. The approach to white light illustrated by the zinc sulphide mixed with zinc-cadmium sulphide is typical of the practical results to be expected.

The fourth paper on television, "Figure of Merit for Television Performance" by A. V. Bedford, RCA Victor, is printed in the November 1937 issue of the *RMA Engineer*, hence only a brief reference to it is included here. It describes the use of resolution charts (one of which is shown in the accompanying figure) to determine the over-all resolution of the received television image, and develops a general mathematical expression for an "over-all resolution figure of merit" which represents the total number of resolvable dots a prescribed portion of the picture in terms of the horizontal and vertical readings given on the chart.

Maloff Describes 3-foot Cathode Ray Tube

I. G. Maloff, RCA Victor, described a cathode ray tube developed to produce large pictures of high brilliance without the necessity of projection. The tube, whose viewing face measures 31 inches in diameter, is intended for experimental use only. The conical shell is welded steel. The viewing end of the tube is glass, two inches thick, and capable of withstanding the pressure of 5½ tons exerted on it by the atmosphere. The tube is continuously pumped, to a vacuum of 10^{-6} mm. of mercury, by a three-stage oil-diffusion pump and fore pump. Electrostatic deflection is used.

The electron gun, a veritable "Big Bertha", measures 8 inches in length and can deliver a beam current of 8 milliamperes. This compares with beam currents of less than half a milliampere in conventional television tubes. The grid voltage necessary for beam cut-off is 150 volts.



Resolution chart used for testing performance of television systems. The wedged shape lines vary in width and spacing from 100 to 300 lines per picture height, while the shaded areas give an indication of the half-tone performance. This is a typical pattern enclosed in the Monoscope tube

equipment far beyond the limits possible with an Iconoscope signal. Other uses suggested are its use to transmit trademarks and other fixed insignia in television programs and for providing backgrounds for television performances, on which could be "mixed" the action supplied by a conventional Iconoscope pick-up.

Bingley Outlines Case for "Narrow-Vertical" Synchronizing Pulses

The second paper on television was presented by F. J. Bingley, Philco, who gave a thorough-going resume of the requirements of the synchronizing pulse which initiates each frame of a television picture. This problem is accentuated by the interlacing problem, since if the beginning of each set of interlaced lines is not very accurately timed, the second set of lines will not fall accurately in the spaces left between the lines of the first set. The resulting "pairing" of the lines will produce a loss of picture detail. With the type of vertical sweep-voltage generator now available for receiver purposes, the pulse which initiates each cycle of the generator must be identical with the preceding and following pulse, otherwise "pairing" will result. To meet this requirement the vertical sync pulses must be accurately timed, and equal in duration and in shape. Furthermore, it is necessary that the occurrence of the vertical pulse shall not interrupt the horizontal sync pulses which initiate each cycle of the horizontal (line-scan) sweep generator, since such an interruption would allow the horizontal generator to fall out of step, causing "bending-over" of the upper lines of the picture.

Several forms of vertical synchronizing pulse have been developed to meet some or all of these requirements. The simple amplitude system, shown in A in the diagram, on page 13 permits equal shape and duration of vertical pulses, but interrupts the horizontal pulses, and hence has been found unsuitable. The second form, B, is the simple serrated type, in which a series of wedge-shaped depressions are inserted in the vertical pulse to accommodate the horizontal pulses. However the horizontal pulses do not occur in the same relationship to the vertical pulses in successive cycles, since the horizontal pulses are displaced by a time equal to one-half the line-scanning time. If the frequency with which the horizontal impulses are sent out is doubled during the frame-sync period, then the shape of the composite sync pulse becomes almost exactly the same for every cycle. However if the integration is taken over a long enough time a slight residual difference occurs between successive cycles, which may throw the frame sync-generator off synchronism. This serrated pulse with horizontal "line-doubling" is the type of pulse at present used by NBC-RCA in their experimental transmissions.

The type of pulse advocated by Mr. Bingley is the "narrow-vertical" type shown in C the type used for several years at the Philco television transmitter W3XE in Philadelphia. Here the amplitude of the vertical sync pulse is greater, by 25 per cent, than that of the horizontal sync pulses, but the duration of the vertical pulse is very much shorter than in the serrated form. An amplitude selector is used to differentiate between the horizontal and vertical pulses, hence only the part of the vertical pulse in excess of the horizontal amplitude is used, and this may be made to have exactly the same shape on each successive cycle. If negative modulation is used, the extra power required in the carrier to handle the increased amplitude is negligible. However if positive modulation is used, about 15 per cent additional carrier power is required. The short duration of this type of vertical pulse makes it a very accurate marker of time, an advantage for maintaining good interlace.

Color analysis of Luminescent Screens

G. A. Fink and R. M. Bowie, Hygrade Sylvania, presented a paper "Specification of Screen Color of Cathode Ray Tubes", which is one of the first attempts to relate scientific color analysis to the luminescence produced by cathode-ray tube screen materials. After outlining the basic theory of color analysis, the authors described three methods of measuring the color components in the light produced. The first is the use of a spectrograph, in which the light is split into its component colors by a prism or grating, and the intensity of the various components measured with a thermopile or by photographic means. The second method, direct visual comparison, makes use of three light sources fitted with tri-chromatic filters and apertures. By combining the outputs of these three sources on a single spot, and by adjusting the size of each aperture, any color may be

A. F. Murray, reported on the present status of the committee's work. A most important announcement was that of the action of the FCC in setting up definite 6-Mc. channels for television transmitters. As shown in the allocation chart given on page 34 in this issue, the assignments to television include seven channels between 44 and 108 Mc., and 12 others between 156 and 294 Mc. In the important region between 40 and 90 Mc. which can be utilized readily with present equipment, there are five channels, but the band is not continuous, being interspersed with amateur, government and aviation services. The committee expressed satisfaction that the assignments are definite and that they meet the specifications as to width suggested by the committee.

Concerning the fundamentals dimensions of the system, Mr. Murray reported "no change" in the number of lines, 441, the number of frames, 30 interlaced 2-to-1, and the aspect ratio, 4-to-3. These standards correspond to those now used in England and Germany, and no immediate change in them is in prospect. There is evidence of a change in sentiment concerning the polarity of transmission, which was tentatively standardized last year as negative. A recent vote of the committee showed a preference for positive polarity of modulation, provided that a satisfactory system of a-v-c is available. In addition there is a growing sentiment in favor of transmitting the d-c component directly in the signal, with the same proviso regarding a-v-c. There appears to be no general agreement on the type of vertical synchronizing pulse to be used. RCA and Hazeltine favor the serrated type of pulse, Philco and Farnsworth favor the narrow vertical pulse, while G. E. and CBS have not yet reached a decision on this point. This item has accordingly not yet been standardized, even tentatively. Evidence supplied by RCA has indicated that horizontal polarization is less prone to noise and variations than vertical polarization, and it appears that standardization on this point may soon be settled. It is also the sentiment of the committee, in the event a satisfactory system of attenuating one sideband in the television signal is developed, that the lower frequency sideband be the one attenuated.

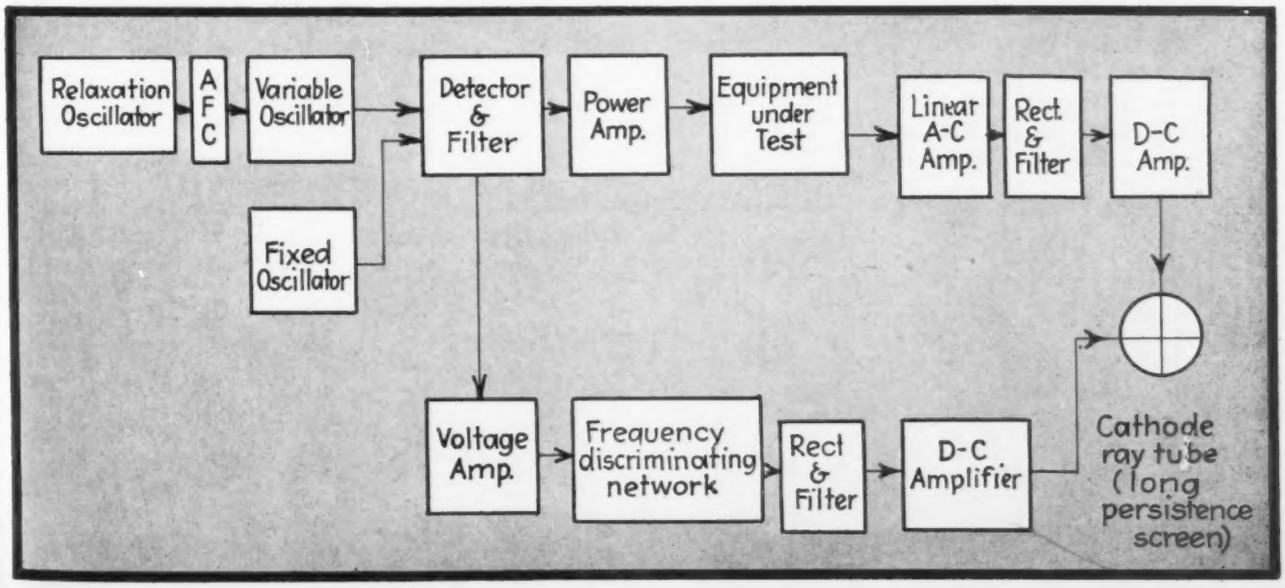
E. H. B. Bartelink, General Electric, presented a mathematical treatment of regeneration in wide-band amplifiers such as are used in television work. He derived a general expression for the stability condition of such amplifiers in terms of the amplitude and phase characteristics of each stage and of the feed-back path. His work applies not only to circuits in which feedback is intentionally introduced but also to cases where feed-back is present inadvertently, as by coupling in the common plate supply of a multistage amplifier.

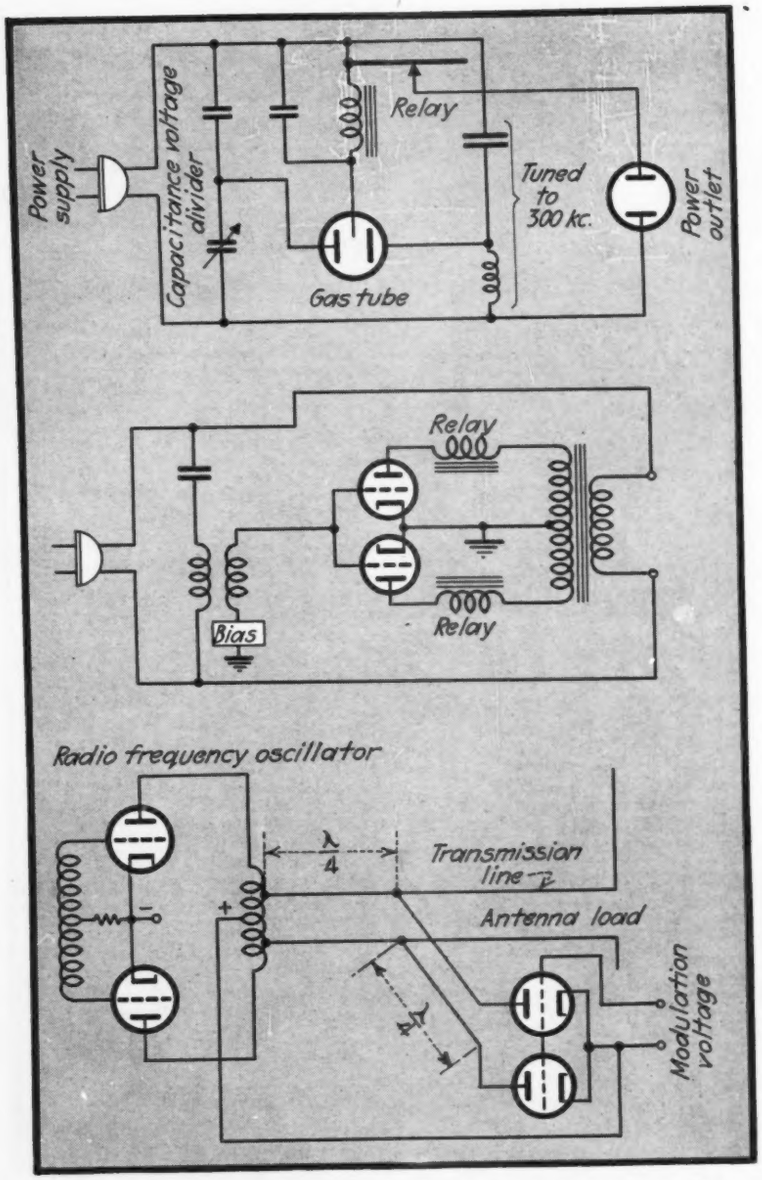
D. B. Sinclair Describes "Parallel" Resonant Measurement Methods

The paper "Parallel Resonance Methods for Measurement of High Impedances a High Frequencies," by D. B. Sinclair, General Radio Company, compared the methods of measuring impedances by substitution in tuned circuits. The series methods now used determine the total series resistance in the circuit. When an unknown impedance is inserted in series with the circuit its contribution to the series resistance may be determined by subtracting the two measured values of series resistance. These circuit resistances are necessarily small, if the resonance curve of the circuit is to be sharp. For high resistance measurements, a parallel circuit may be used in a similar manner. For this type of parallel circuit, methods are available to find the effective parallel conductance (or inversely the resistance) using equations of the same form as are used for the series methods. In the parallel case, if an unknown conductance is connected in parallel, its value may be determined by subtracting the two measured values of circuit conductance, one with, the other without, the unknown present. Mr. Sinclair's analysis reveals that errors

(*Continued on page* 67)

Block diagram of the cathode-ray curve tracer for recording the frequency-response curves of audio-frequency apparatus. A beat-frequency oscillator is varied by an a-f-c circuit operating under the control of voltage from a relaxation oscillator. The varying beat frequency is impressed on the equipment under test, and also used to fix the horizontal frequency scale





Top: elementary teledynamic control circuit. A 300 kc. carrier sent by the control unit causes the gas tube, held on the point of ionization by the capacity voltage divider, to pass current, closing the relay. The set is thus turned on without "standby" power being consumed. Center: a tube circuit for selecting opposite phases of modulation in the 300 kc. carrier. Above: fundamental circuit of the resonant-line modulation system for television transmitters

The light obtainable from the screen is very great, considerably in excess of the value recommended for motion picture projection by the S.M. P.E., (3.5 candles per square foot) delivering 40 candles per sq. foot. The screen can be viewed in daylight without difficulty. The luminescent coating is applied to a flat glass plate contained within the tube.

"Resonant-Line" Television Modulation System Described by Parker

A television modulator capable of handling a sideband width in excess of 5 megacycles was described by its inventor, William N. Parker of Philco. Mr. Parker explained that the conventional grid modulation used in television transmitters suffers from the inherent difficulty of creating frequency and amplitude voltage changes across a tuned circuit. The suggestion that the modulation be applied between the output tank of the amplifier and the antenna led to the development of an entirely new modulation system. Essentially the system is an absorption method. The impedance which absorbs the energy during modulation is the impedance presented by one end of a quarter-wave resonant line, when the impedance across the other is changed in accordance with the modulation.

The layout of the system is shown in the accompanying diagram. The radio frequency is generated in a conventional oscillator or amplifier and applied to a quarter-wave transmission line. At the end of this line a junction is made to another quarter-wave transmission line which is in turn terminated in the plates of two modulator tubes. The cathodes of the modulator tubes are connected to the positive terminal of the high voltage supply, while the modulating voltage is applied between the modulator grids and cathodes connected in parallel. The junction between the transmission line and modulation line connects to the antenna through another transmission line. The impedance between the modulator tube plates changes in accordance with the modulating voltage, and this change in impedance is transferred, by the impedance-inversion characteristic of the quarter-wave line, to the junction point in the antenna circuit. Here absorption occurs, changing the output power in accordance with the modulation.

In a demonstration of the system, a small transmitter operating on 200 Mc., was modulated with a voltage whose frequency was varied up to 20 Mc. The beat between the carrier and the modulation was then received in a conventional short-wave receiver. It was shown that the 200 Mc. carrier could be modulated to 20 kc. with the same ease as at 5 Mc. or lower. In general, in the resonant line method, the maximum modulation frequency can be 10 per cent as great as the carrier. In the 50 Mc. television band, therefore, a maximum side-band width of 5 Mc., or twice that contemplated in the tentative R.M.A. standards, can be accommodated. Slides showing the application of the system to a one kw. transmitter (W3XE at Philadelphia) were shown. In this transmitter the system has operated with great success for about two years.

A. F. Murray Reports on R.M.A. Television Standards

The Chairman of the RMA Subcommittee on Television Standards,

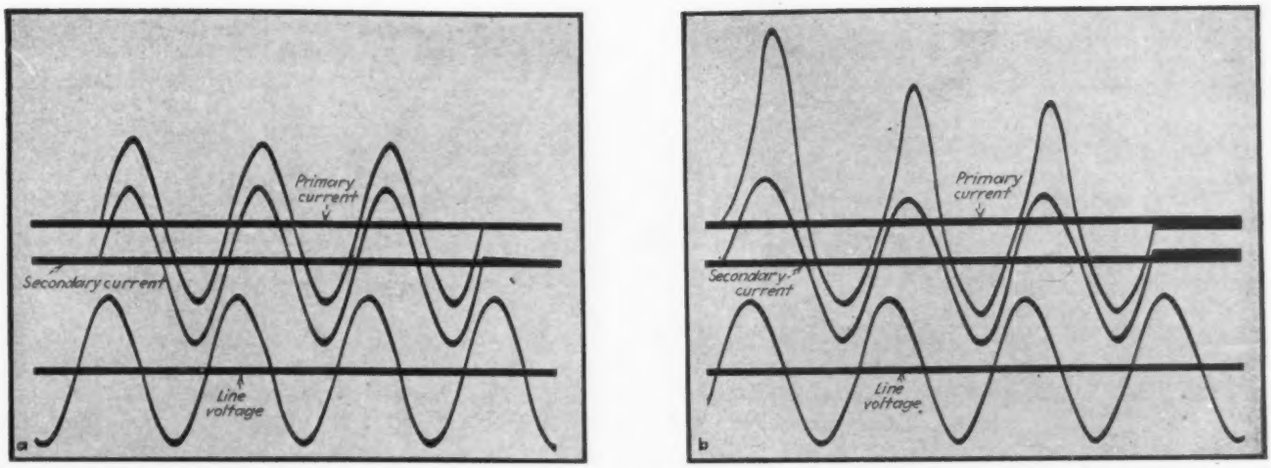


Fig. 6—Oscillograms showing (a) firing for minimum transient and (b) firing near zero point of line-voltage wave

ondary currents of resistance welders. A small air-core coil placed in the throat of a welder so as to be coupled inductively to the secondary load circuit provides a convenient method for obtaining a voltage which is a function of the secondary current. The voltage e induced in this air-core coil, which may be called the "pick-up" coil, is related to the secondary or welding current in accordance with the expression

$$e = M\ di/dt \quad \ldots\ldots\ldots\ldots\ldots (1)$$

where M is the mutual inductance between the secondary loop of the welding circuit and the pick-up coil in the throat, and di/dt is the rate of change of current in the secondary circuit at any instant. With the highly inductive secondary circuits usually encountered in most welders the wave-shape of the voltage induced in the pick-up coil corresponds very closely to that of the secondary voltage of the welder transformer. Figure 8 shows an oscillogram which illustrates this point and Fig. 4 shows the method used for taking curves V_1 and V_2 of this oscillogram.

Although the pick-up coil provides a small and lightweight means of obtaining a voltage that is a function of the secondary current, without disturbing the load circuit conditions, it does not in itself provide a means for deflecting an oscillograph element in accordance with the wave form of the welding current. However, this may be accomplished by replacing resistor R of Fig. 4 by a reactor as shown in Fig. 3. The instantaneous current i' flowing through the oscillograph element is then related to the instantaneous voltage e induced in the pick-up coil in accordance with the following expression:

$$e = L\ di'/dt \quad \ldots\ldots\ldots\ldots\ldots (2)$$

Where L is the inductance of the reactor and where the resistance of the circuit is assumed to be negligible. Then if e is eliminated by combining Eq. (1) and (2)

$$M\ di/dt = L\ di'/dt \quad \ldots\ldots\ldots (3)$$

Since M and L are circuit constants, then

$$i' = ki + C \quad \ldots\ldots\ldots\ldots\ldots (4)$$

and at the boundary condition

$i' = 0 = i$ therefore $C = 0$ and

$$i' = ki \quad \ldots\ldots\ldots\ldots\ldots (5)$$

where k is some constant determined by the circuit constants; therefore the currents flowing through the oscillograph vibrator has the same wave-form as the current flowing in the secondary circuit of the welder. Figure 1 shows the complete circuit used to take the oscillogram of Fig. 8, where V_2 is the element for recording the secondary wave-form. The reactor L should be an iron core reactor with a small air-gap.

Figures 6a and 6b show oscillograms taken on a welder, using the pick-up coil method for recording the secondary current. Figure 6a was taken with the welder control "firing" at the proper point in the line-voltage wave for minimum transient. Figure 6b was taken with all conditions the same as for Fig. 6a except that the control "fired" near the zero part of the line-voltage wave. This oscillogram shows the high primary current transient caused by saturation of the transformer core, the secondary load transient caused

(*Continued on page* 48)

Fig. 7—Oscillogram made with pick-up coil and resistance

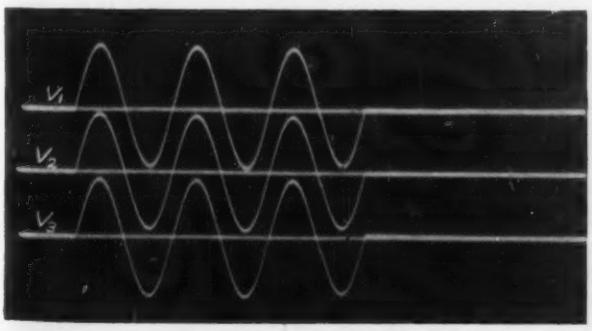
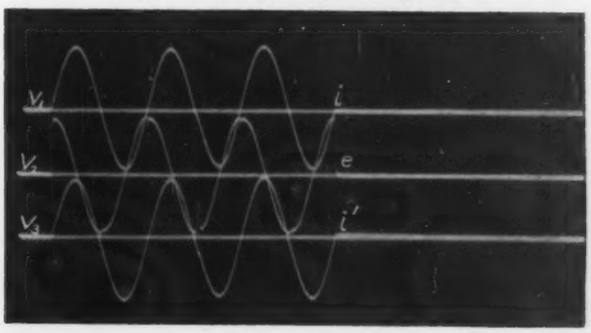


Fig. 8—Oscillogram of welding circuit



Recording Resistance-Welder Secondary Currents

By H. W. LORD
General Electric Company
Schenectady, N. Y.

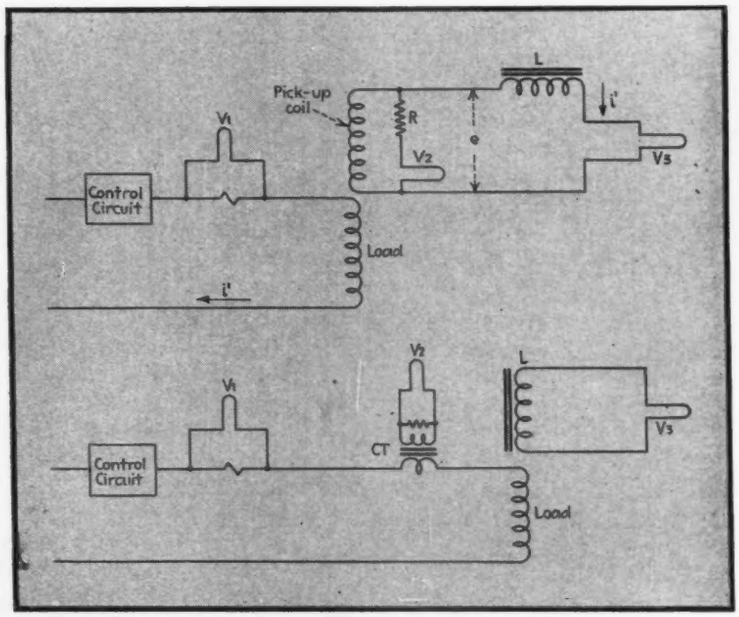


Fig. 1—(above) Circuit for making oscilligrams of Fig. 8. Fig. 2—Connections for making Fig. 6

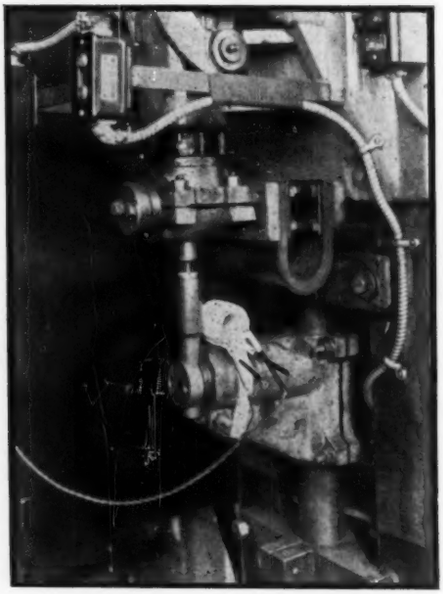


Fig. 5—Pick-up coil on 150 kva. welder

BECAUSE of the high currents (300,000 amperes in some cases) delivered by resistance welders, oscillographic recording of the secondary currents of resistance welder transformers presents several problems to the engineer who desires to make such tests.

It is the purpose of this paper to discuss the advantages and disadvantages of some of the methods commonly used, and to describe a new method, the "pick-up" coil method, which may prove a useful tool to the engineer interested in studying resistance welders under various conditions of loading and timing control settings.

The Shunt Method

This method has the advantage of allowing one to calibrate the shunt before installation; the oscillograms, therefore, will yield a quantitative as well as qualitative result. However, since the vibrator of an oscillograph such as the General Electric Company's type PM12 requires about 100 millivolts for reasonable deflections, power is consumed in the shunt at the rate of $0.1 \times 300{,}000 = 30$ kilowatts when measuring a 300,000 ampere circuit. Under such conditions and with a welder operating on a 10 per cent duty cycle, the shunt would have to dissipate 3 kilowatts continuously. This would require a shunt of comparatively large size. Moreover, the inherent inductance of the shunt would probably be sufficient to distort the wave form to a noticeable degree. Further, this method has the disadvantage of being difficult to connect into a welding circuit.

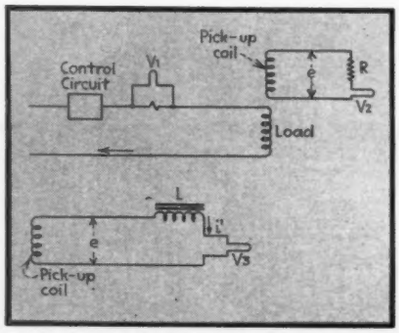


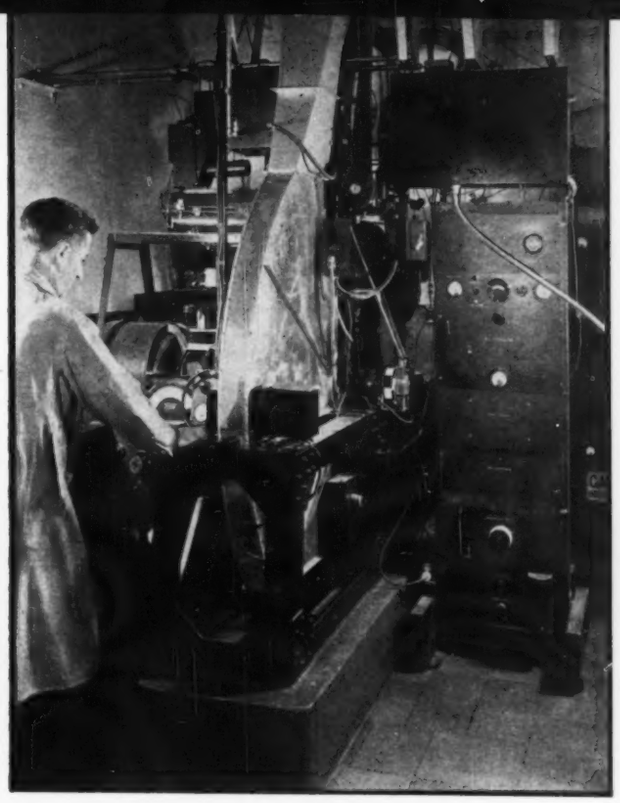
Fig. 3—(below) Substitution of inductor for aircore coil of Fig. 4 (above)

The Current-Transformer Method

A current transformer with a core which may be slipped over the arms of a welder could be used to obtain oscillograms and to measure the secondary current. However, a current transformer capable of handling 300,000 amperes without ratio changes or wave-form distortion would weigh several hundred pounds and would be difficult to move. The size of such a current transformer would prohibit its use on welders having small throat clearance.

"Pick-up" Coil Method

It is expected that the following discussion of the "pick-up" coil method will demonstrate its advantages over either of the two methods just described, for recording sec-



Mechanical scanning disc in the Bell Telephone Laboratories which slices the motion picture frame pictures into elementary areas

The entire coaxial line, including repeaters at ten mile intervals is equalized over the million cycle band, and delay equalizers have been inserted to reduce phase distortion to less than 0.25 microsecond (corresponding to the time required to scan a distance equal to one-half the width of the scanning spot.)

Synchronizing is obtained from light shining through holes drilled in the scanning disc which produces (in a phototube) the line scanning frequency of $240 \times 24 = 5760$ cycles per second. This frequency is then used to modulate a 72 kc. carrier and this modulated carrier is sent over the cable in the unused region between 0 and 100 kc. At the receiving end demodulation is used to obtain the line scanning frequency of 5760 cps. and subharmonic generators to obtain its 240th subharmonic (24 cycles per second) which is used as the frame scanning frequency.

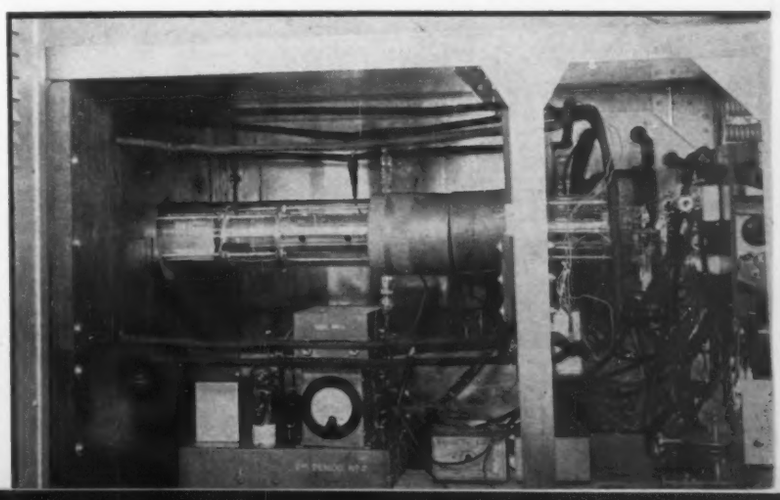
The receiver uses a conventional cathode ray tube producing a picture about 7 by 9 inches in size, green in color. The tube is scanned by electrostatic deflection, the sweep voltage generators being controlled by the 5760 cps. and the 24 cps. frequencies previously mentioned.

Perfect synchronism and even illumination obtained

The received image is distinguished by several features. In the first place there is some flicker, especially in the brighter portions of each scene, since no interlacing is used. In the second place the line structure of the image is visible at a distance of perhaps six times the picture height, since only 240 lines are employed. But aside from these limitations imposed by the dimensions of the system, the picture quality was excellent. There was no noticeable geometrical distortion of the picture. The contrast range was excellent. The synchronism, throughout the 12 minutes of the demonstration, was perfect. Even when sudden changes of over-all brilliance occurred in the film—which ordinarily throw the picture out of step—there was no perceptible loss of line or frame synchronism. The illumination over the face of the image was completely uniform, greatly adding to the apparent contrast and intrinsic interest in the picture. The illumination level was low, presumably to inhibit the effect of flicker on the eye, but it was perfectly adequate in a darkened room. The outstanding characteristic of the image was the crispness of the detail along each line, the sharp demarcation and detail in the shadows, and the freedom from phase "hang-over" effects.

The high quality of the picture is explainable on several counts. First, the amplifier and modulator system was very highly engineered within the limits of the million cycle band. Second, since no iconoscope was used, there was no shading (uneven illumination) problem. Third, since non-interlaced sequential scanning was used, the ability to preserve detail in each line was greatly enhanced, since in interlaced pictures, improper timing of the lines is apt to reduce definition. Fourth, the use of a separate channel for synchronism and the fact that the vertical and horizontal synchronism frequencies were integrally related, made for comparative simple and reliable sync circuit performance.

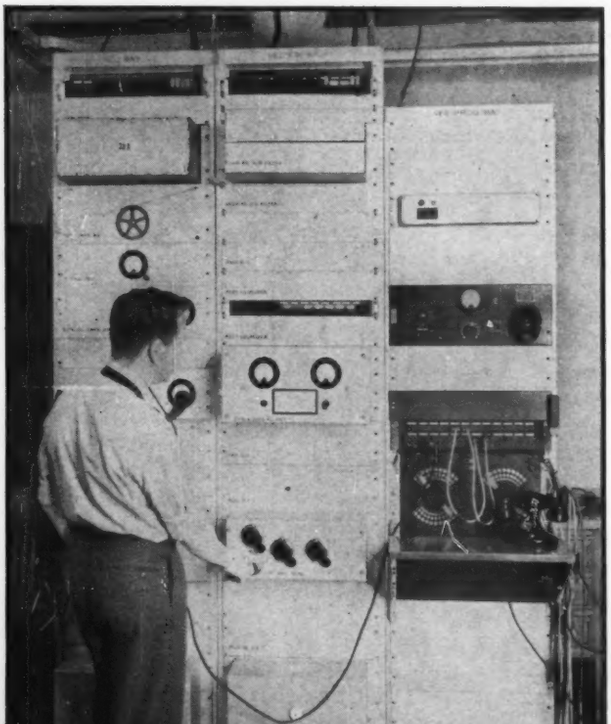
In connection with the demonstration, Dr. Frank B. Jewett, President of the Bell Laboratories, issued a statement to the effect that while the demonstration was not intended to demonstrate television, the system did show a "unique and economical utilization for television currents of the frequency band of a long coaxial cable". This referred to the fact that single side-band transmission was used to transmit the video signal, made possible by double modulation and the use of very precise filter structures. The frequency spectrum was thereby placed 100 kc. above zero, thus avoiding the low frequencies where transmission and amplification are difficult to accomplish. This arrangement, together with the system used to reduce phase distortion, represent new departures in the communications art.



The "socket end" of the cathode ray receiving tube

Bell Labs Test Coaxial Cable

Video signal, produced by scanning film at 240 lines, 24 frames per second, is applied to coaxial system linking New York and Philadelphia. Results compare favorably with 441-line images shown elsewhere



Carrier current equipment at the Philadelphia end of the New York — Philadelphia coaxial cable

ON NOVEMBER 9, while many of the leading television engineers were in Rochester hearing papers on the video art, the Bell Telephone Laboratories demonstrated for the first time the transmission of television images over the million-cycle coaxial cable system recently installed between New York and Philadelphia. This first demonstration was held for executives of the A. T. and T. and operating Bell Telephone Companies, but subsequent demonstrations were made for members of the technical press. Many who viewed the demonstration felt that the images produced, while based on the limited possibilities of 240 lines, and 24 frames without interlacing, were the equal to, if not actually superior to the 441-line, 30-frame images recently demonstrated in New York and Philadelphia. The system, having been proved out on its original plan of a one-million-cycle band-width, will shortly be returned to further research looking toward a two-million-cycle band, capable of handling the definition of a 350-line television picture having, of course, superior detail.

The intended use of the coaxial system is, in part, the transmission of carrier channel telephony, 240 separate channels being carried simultaneously, each on a 4 kc. band-width. By a double modulation scheme the carriers of each telephone channel are spaced between 60 and 1,020 kc. In testing the multiple channel system, the channels were connected end to end, so that the equivalent length of the circuit was 3800 miles, looping back and forth through the same cable some 45 times. Satisfactory telephone service was possible over this arrangement.

To test the entire range of the cable with *one* signal required use of some sort of video generator. The type of generator decided upon was a mechanical scanner, used in conjunction with ordinary motion picture film. The frame repetition rate of such film is 24 per second. To fill the available band width of 1000 kc. a picture of 240 lines was decided upon, making the nominal channel width $\frac{1}{2} \times 240^2 \times 4/3 \times 24 = 960$ kc.

The scanner is a six foot steel disc, rotated at 24 revolutions per second (1440 rpm), in which are set 240 high speed lenses, each located at the same radius from the center. The lenses focus a light beam on the film, which is passing at a constant rate of speed, the beam being square, about 0.003 of an inch on a side. Each lens thus scans one line in each frame of the film. The light, passing through the film, is collected by a phototube containing an electron multiplier, the multiplier being necessary to increase the current output. The output of the multiplier, containing frequencies from 0 to 800 kc. is then applied to a double modulator which raises the entire spectrum 100 kc. The region between 0 and 100 kc. is then available for the sound channel and for sending synchronizing pulses. Furthermore, the low frequencies in the video signal, which might be interfered with due to shielding difficulties in the cable, are removed to a high point in the spectrum.

tubes. These tubes are supplied with a fixed bias somewhat greater than cut-off which is applied in series with the output of the control rectifier so that the two voltages are in reverse polarity. If a signal is applied to the input of the chopper and gradually the level is increased, the output will increase in direct proportion to the input as in any linear amplifier or network until the rectified output of the control amplifier has discharged C_1 sufficiently to reduce the bias on the control tubes to cut-off. When this point is reached further increase in input level will simply shunt a lower and lower resistance across the attenuator network, increasing the loss with the signal increase.

It is necessary that the loss increase in direct proportion to the signal if the output is to be held at a certain limit. This would not ordinarily be true were the control amplifier supplied directly from the attenuator input. Under proper design conditions the action would then reduce the output as the signal increased. To meet this problem it was found necessary to make the input to the control amplifier a mixed function of the input and controlled voltages. With the proper mixture the input-output curve can in this way be made to follow practically any desired law.

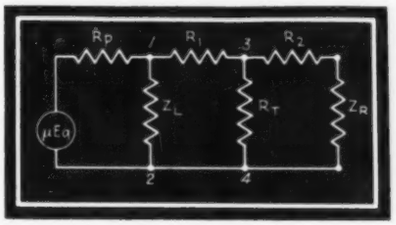


Fig. 2—Equivalent circuit of attenuator section

In designing the volume limiter, particular attention was given to the minimizing of amplitude and frequency distortion for all degrees of operation. Z_s and Z_r were adequately loaded to prevent impedance variation and impedance correcting networks were applied where necessary. The resistance R_1 was made sufficiently large to insure that the load facing the plate circuit of the first amplifier would not be less than the combined plate resistance for the maximum attenuating condition. With this as a minimum for R_1, R_1 and R_2 were selected in terms of the desired attenuation range and practical values of Z_s and Z_r.

It is practically impossible completely to do away with surges caused by the changing current in the attenuator tubes during operation. For this reason closely matched attenuator tubes must be selected and the input to the attenuator must be sufficiently great to override the remaining surge.

The operating time, which is defined as the time taken to reduce a specified overload to normal level, may be increased or reduced by increasing or reducing respectively the impedance facing the control rectifier plates, or the capacity C_1. The releasing time is proportional to R_2 times C_1. These may be selected from listening tests. In general, if the operating time is too low, a copious amount of unpleasant distortion will result, while if it is too high overloads of too long a duration will be passed to the output. The releasing time should be high enough to assure that tremolo effects will not be destroyed.

In adjusting the instrument for proper operation, the amplitude-frequency characteristic should be made flat over the desired range to the attenuator input as well as to the output terminals. The control rectifier output must also have a flat frequency characteristic. Voltage runs should be made for various settings of the second amplifier input and one selected which will give the required input-output curve.

The first amplifier, which is a 6A6, has a rather high effective grid shunt capacity and if a high impedance input transformer is used it will be necessary to apply compensation. Both the input and output amplifiers operate into relatively high load impedances. This assists in keeping the distortion low and indicates that the output impedance is much lower than the impedance into which it is designed to work, which is 500 ohms.

The instrument worked out exceptionally well; the amplitude-frequency characteristic was successfully made flat within ½ db from 30 to 10,000 cycles. The distortion at 400 cycles for normal input level was unmeasurable and was less than 1% when the input was increased 20 db (peak of attenuation range). The hum level was — 70db. Normal input level was — 26db, delivering an output of .006 watts into 500 ohms. The attenuation range was 20 db being amply sufficient to meet any normal monitoring situation.

Design Data

Sizes of all parts are included in the schematic diagram of Fig. 1 for those who may want to build an identical device. If a variation is necessary, the following considerations will be helpful in selecting a desired attenuator combination:

$$R_1 = \frac{Z_1 R_p}{Z_1 - R_p} \qquad Z_s = \frac{Z_1 R_p}{Z_1 + R_p}$$

Z_s = The impedance looking backwards from terminals 1, 2.

Z_1 = Plate load with attenuator section disconnected.

R_p = Plate resistance of amplifier preceeding attenuator unit.

Non-operative loss = minimum when $Z_s + R_1 = Z_r$ and $R_2 = 0$ (2)

$$\text{Attenuation range} = 20 \log_{10} \frac{(Z_r + R_2)(Z_s + R_1)}{R_t (Z_s + R_1 + Z_r + R_2)} \quad (3)$$

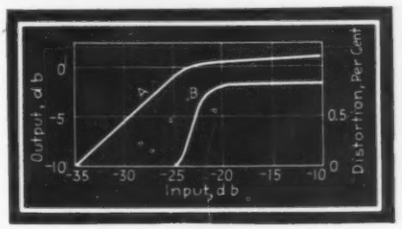


Fig. 3—Characteristics of the peak chopper. A — input-output; B — 400 cycle distortion

R_t = combined attenuator tube plate resistance at zero bias.

$$E_2 = \frac{E_1 Z_r}{Z_s + R_1 + Z_r + R_2} \quad (4)$$

E_1 = Open circuited voltage at Z_s when signal is sufficient to reduce attenuator tube bias to cut-off.

E_2 = Voltage supplied to Z_r when signal is sufficient to reduce attenuator tube bias to cut-off. (This is the maximum input voltage to the second amplifier.)

It can be shown by a rather involved differential equation that

$$\frac{\text{Attenuation range}}{\text{Non-operative loss}} = \text{maximum when } Z_s + R_1 = Z_r + R_2.$$

Therefore from (3)

$$R_1 + Z_s = R_2 + Z_r = 2R_t \left(\text{Antilog } \frac{\text{Attenuation range}}{20}\right) \quad (5)$$

In designing the attenuator section it must be remembered that the amplifier preceeding the attenuator unit must be capable of delivering $\left(\text{antilog } \frac{\text{attenuation range}}{20}\right)$ times the required value of E_2 without distortion.

In all of these equations the attenuation range is considered as positive.

A Volume Limiter

A peak chopper for broadcast transmitters, which raises average level of modulation; makes impossible over-modulation for any extended period

By C. F. SHEAFFER
KTUL, Tulsa, Okla.

THERE has been an increasing interest of late in the use of peak choppers, or volume limiters in conjunction with amplitude modulated transmitters.

Their use affords two very decided advantages:

1. The average level of modulation is increased.

2. Over-modulation, for any notable length of time, is within the limits of the chopper, impossible.

The device described in this paper was designed for use in conjunction with the Barnsdall CBS Program, originating in Tulsa, Oklahoma. It is equally adaptable, however, to the use suggested.

Essentially the "chopper" is an attenuating network the loss of which is controlled by the amplitude of the applied signal. In tube operated devices this is accomplished by rectifying and filtering a part of the signal voltage and applying it either to control the gain of an amplifier, or to add loss in the circuit by changing the plate resistance of a tube.

Several methods were examined but were not entirely satisfactory. The one finally chosen offered four distinct advantages all of which could not be obtained in any one of the others. They are as follows:

1. Both the operating and releasing time can be controlled independently.

2. Current surges inherent in tube operated devices are effectively blocked out allowing a considerable reduction in operating time.

3. Current drawn by the attenuator tubes is indicative of the amount of attenuation present making it possible to read the over-shoot on a suitably calibrated meter.

4. No elaborate filtering of the rectified control voltage is necessary due to the plate bucking arrangement of the attenuator tubes.

A schematic diagram of the complete device is given in Fig. 1 together with the type and sizes of parts used. Amplifiers incorporated in the input and output circuits make possible the use of the desired levels as well as do away with impedance variations which would otherwise affect the input and output circuits. The attenuator section consists of an H type resistance network, the shunt of which is formed by the plate resistance of the attenuator

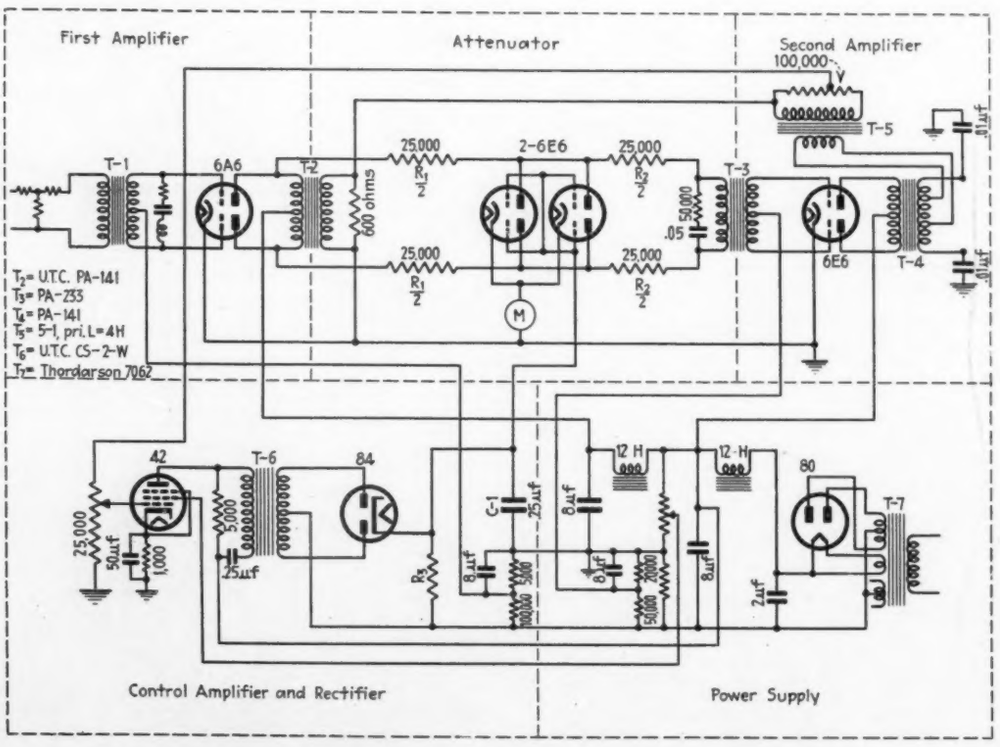


Fig. 1—Diagram of the volume limiter with circuit constants

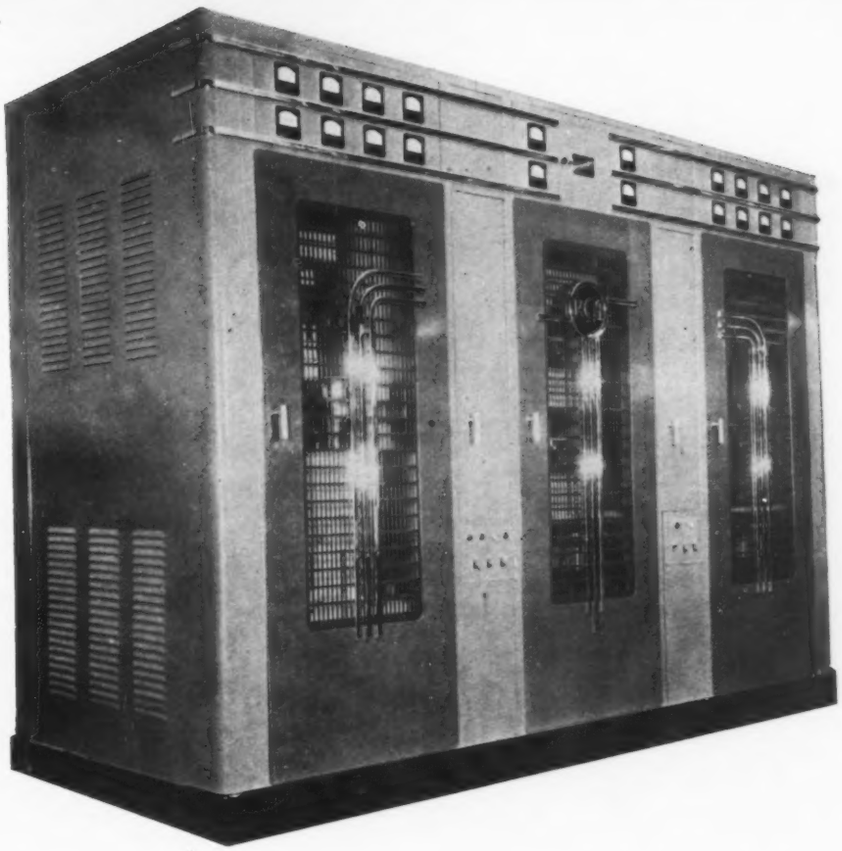


Fig. 1—Front view of the new 10 kw., 6-20 Mc. transmitter at W2XE, short wave station of the Columbia Broadcasting System, Wayne, N. J.

W2XE SHORT WAVE TRANSMITTER

By JOHN P. TAYLOR

A DECADE of experimental short-wave broadcasting, and four years of all-band receiver production have failed to define the possibilities of international broadcasting. Nevertheless, there are signs and portents that here is another of radio's "watched pots" which may be getting ready to boil. Foremost of these indications is the fact that at least three short-wave broadcasters have new transmitting plants planned or under way. The severalfold increases in power, plus new equipments throughout, must represent more than premise.

First of these three installations to approach completion is that of the Columbia Broadcasting System. Comprising complete new equipment for W2XE (located at Wayne, N. J., in the same building as WABC) this installation features an especially designed factory-built transmitter which sets up entirely new standards in this field. As the newest development—and hence most recent commentary on the advance in short-wave broadcasting—this installation has many features of general interest.

Technically the new equipment of W2XE is of more than usual interest in that it marks a definite turning point in the development of equipment of this type. With advertising revenue prohibited and with little governmental encouragement American broadcasters have in the past been loathe to undertake the expense of installing permanent equipment for operation on the international frequencies. As a result, while American short-wave stations have held their own with stations of other countries, with respect to power, the equipment made use of have in general been of a decidedly experimental nature. This is not to imply that these transmitters have not been up to the required performance standards, but they have been of composite construction, often using experimental type tubes. In more or less degree they have lacked the advantages of standardization and operating convenience associated with modern broadcast transmitters. By contrast with this, the new transmitter of W2XE is a finished permanent-type equipment which brings together all of the recent developments in radiophone transmitter design. It is the first high-power short-wave transmitter designed from beginning to end specifically for broadcast use. It is capable of performance fidelity equivalent to the finest new broadcast transmitter; incorporates such features as high-level modulation, low temperature coefficient crystals, and advanced design of power and control circuit features. In appearance and constructional design it follows the modern lines developed in broadcast transmitter design.

Inductance Tuning

Old in principle, new in practice, inductance tuning of broadcast receivers offers several advantages according to demonstration of 0.54—65 Mc receiver before Radio Club of America. Fine adjustment in tuning high frequencies is possible

BEFORE the Radio Club of America on November 18 Paul Ware of P. R. Mallory described and demonstrated a most interesting system of tuning a superheterodyne or a t-r-f receiver by means of variations in inductance as contrasted to the present-day method of tuning by capacity variations. The inductance in this case is a single layer solenoid which rotates with the tuning dial. On this coil is a phosphor bronze rider which makes contact with bare silver-plated hard drawn copper wire and effects the tuning. Several of these coils may be ganged together. Across each coil is a fixed capacity which is about 1200 micro-microfarads for the broadcast band and 50 micro-microfarads for short-waves. These large fixed capacities swamp variations in capacity due to changes in tubes or to circuit variations.

Advantages of the system of tuning by inductance rather than by capacity cited by Mr. Ware are ease of alignment; greater frequency coverage per switch position; lower variations between units due to variations in wiring; better oscillation in superheterodynes; switchless skipband design; push-button tuning without the necessity of automatic frequency control; ease of getting band spread without extra gadgets.

The receiver demonstrated covered from the broadcast band to 65 megacycles with three switch positions. Mr. Ware stated that the cost of his system compared to condenser tuning could be stated in this manner; if an all-wave receiver is to be built with two switch positions for inductance tuning and three positions for condenser tuning, the new method would be cheaper. On the other hand if three switch positions are used in both sets, the cost would be about the same. The inductance system, however, would have a much better tuning coverage of the desired frequencies. For example it seems to be possible to have an all-wave set in which certain portions of the spectrum can be spread out to occupy a large position of the tuning scale with all other portions covered but in a hurry. Thus the important frequencies can be covered slowly and accurately; the others can be jumped over but without any actual skip bands.

The accuracy of alignment and tuning is high compared to capacity tuning. For example a condenser is restricted to a 180 degree rotation. Thus the tuning dial must effect all the tuning in this half-circle of motion. On the Ware coils, however, there are 30 feet of wire for the broadcast band. Since the contact can cover each quarter-inch of this thirty feet the total dial motion amounts to the number of turns times 360 degrees and the accuracy amounts to one quarter inch in 30 feet. It would be expensive to get this sort of motion with a condenser unless one resorted to gears such as now go into General Radio precision condensers.

This very fact of long tuning range presents a difficulty—that of manually tuning the system. On Mr. Ware's demonstration receiver, it was necessary to install a crank with which the tuning system was literally wound up to the required frequency. Motor tuning, however, would simplify this tuning tremendously and make inductance tuning practical.

The question of tracking in a superheterodyne naturally arises. Using inductance trimmers it seems possible to equal and perhaps better tracking when accomplished as in present day circuits. As a matter of fact the system makes it possible to have four cross-over points with the variations due to mistracking somewhat less than with a three cross-over capacity trimmed system. So far as feedback is concerned, Mr. Ware pointed out that a two-gang job with a tight metallic shield over the two coils operated without disturbing feedback. In this case the broadcast band coils were about 2¼ inches in diameter with a shield about 4 inches in diameter.

On the question of life and noise, it was stated that the receiver on demonstration had been tuned the equivalent of 30,000 round trips of the contactor which amounted to several hundred miles of motion. No noise developed in this period. Experiments were also made to determine the noise that came about after the receiver had been out of service for an appreciable period. Here, again, no noise seemed to arise. Since the inductance with the moving contactor need not be hermetically sealed, to prevent development of noise, the system is inherently quiet. It is free from Mocrophonics.

In addition to the possibilities of inductance tuning for radio receivers is the advantage of it when used in signal generators. Mr. Ware indicated that he had constructed a generator covering a range of 90 kc. to 35 Mc. which delivered 2 volts into 20 ohms and which had constant output. This was a MOPA circuit. Using a 954 acorn tube it was possible to make an oscillator covering the range of 40 to 150 megacycles.

Discussion brought out the fact that with small shunting capacities, one would be able to work near the natural wavelength of the coils; that a typical coil had 53 turns on a 2 inch diameter form and would cover a range of from 0.54 to 18 megacycles; that in actual practice small "end" coils were connected to the tuned inductance, these additional coils having values of Q higher than the tuning inductance. These end coils brought up the overall Q considerably with evident advantage. The use of conical coils to improve straight line tuning and several methods of increasing the alignment ease were brought out in the ensuing discussion.

and utilize interstage transformers. In the first stage 843's are used, 845's in the second stage, and 891's in the modulator stage. The latter, operating Class B, modulates the power amplifier stage.

The power supply consists of three separate rectifiers. The first employs a pair of 866-A's and furnishes 250 volts to the plates of the oscillator and buffer stages, in addition to supplying bias voltage for all stages of the transmitter. The second employs three 872-A's in a three phase half wave circuit and supplies plate voltages for the two doubler stages, the intermediate power amplifier stage and the second audio amplifier. The third is the high-voltage supply for the modulator and power amplifier stages. It consists of twelve 872-A's in two banks, each of which is in itself a full-wave three-phase rectifier, the two banks being connected in series. This arrangement furnishes 10,500 volts with convenient taps at 50% and 75% of maximum. It has the advantage of using small tubes which are inexpensive and may be replaced at a stipulated number of hours, thereby avoiding frequent time losses due to tube failures.

The control system of the transmitter represents a marked advance in this field. It closely follows the systems worked out for the more recent designs of broadcast transmitters and is the equal of these latter in every respect. All units are interconnected and so arranged that either manual step-by-step or full automatic starting may be employed. Circuits are interlocked so that voltages are applied in proper sequence and the necessary time delays assured. The usual devices are employed to protect the equipment in case of excessive plate current, inadequate water flow, or high temperature of the cooling water. An automatic induction voltage regulator is supplied so that variations in line voltage up to ±10% are automatically corrected.

Frequency Changeover

Short-wave broadcast transmitters are operated at several frequencies during the day in order to obtain optimum results according to the diurnal variations of the ionosphere and the desired direction of transmission. Since it may often be required to transmit successive programs at different frequencies, some method of quick frequency changeover is highly desirable. If instantaneous changeover is to be accomplished, retuning of stages is obviously impossible. In order to avoid this, use has been made of an arrangement previously employed in commercial communication transmitters (where a somewhat similar problem exists). Changeover from one frequency to another is accomplished by means of a single switch; the operation is practically instantaneous and no program time is lost. The primary feature of this arrangement is the provision of alternative tank connections in all r-f stages. In the four low-power stages, which are housed in the center unit of the transmitter, the alternative connections consist of independent tank circuits, each complete in itself. The arrangement of these tank circuits is illustrated in Fig. 4. In the case of the power amplifier stage, the changeover is accomplished by means of taps on the tank coil so arranged as to short circuit portions of the coil when changing to a higher frequency. In addition to these changes in the r-f stages, it is also necessary to reduce the voltage on the power amplifier at the higher frequencies (the maximum allowable power out-

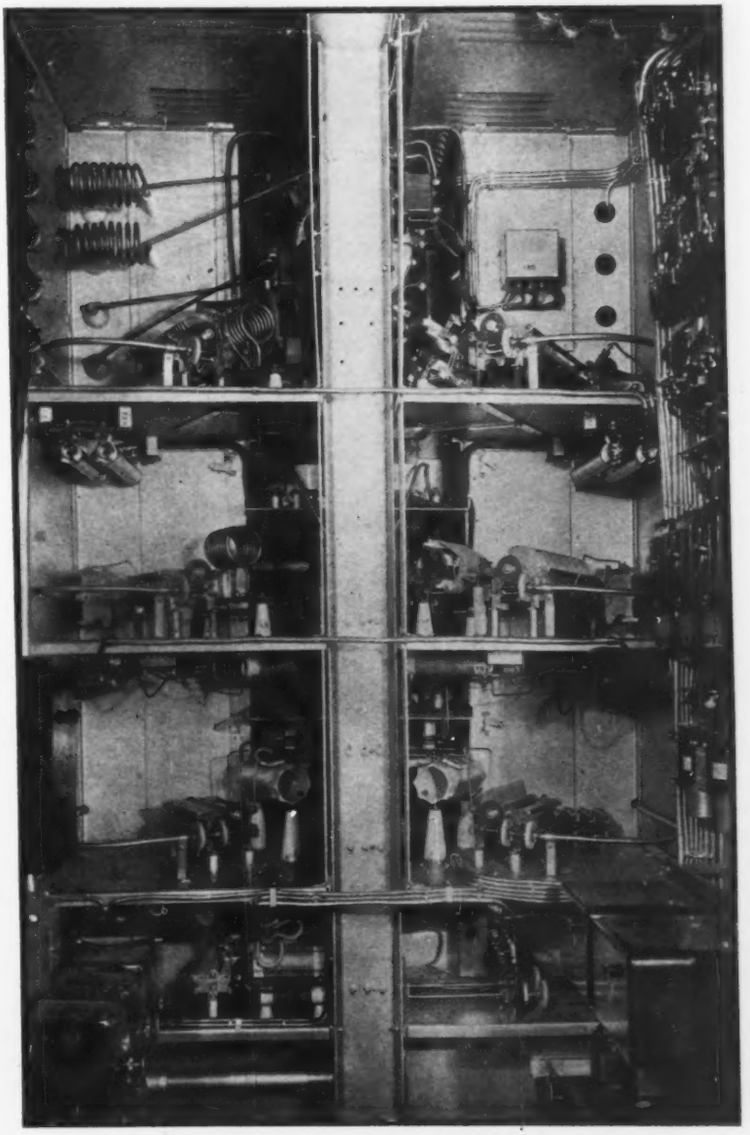


Fig. 4—Close-up of rear of exciter unit showing duplicate tank circuits in each of the four low-power stages. Tuning is accomplished by flexible cable coupling the condenser shaft with the panel dial

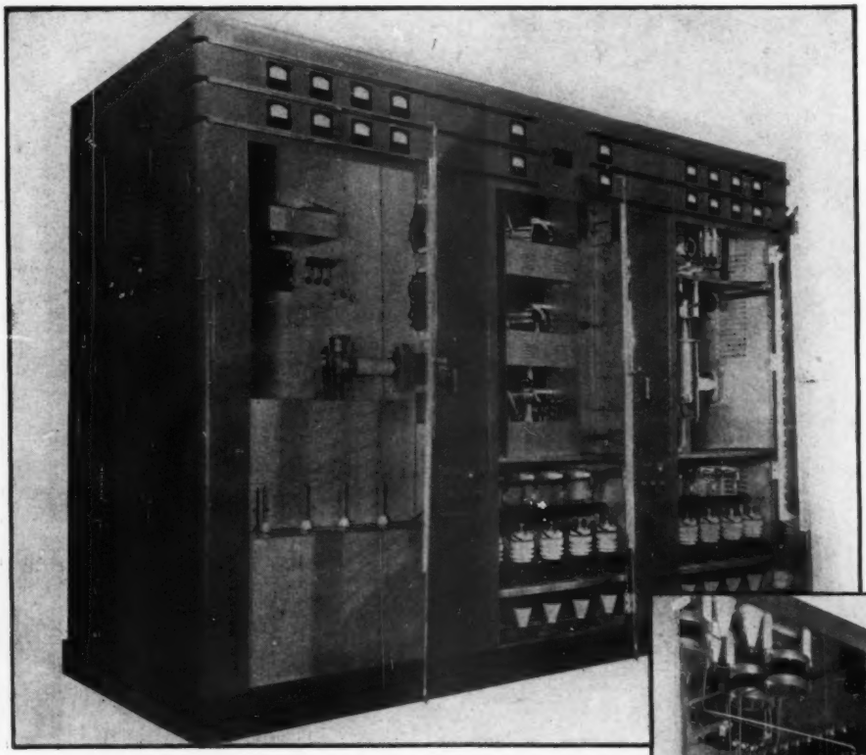


Fig. 2—Front view with main doors open to show the unusual accessibility of all parts. Tuning controls are located behind the two small doors which are here shown closed

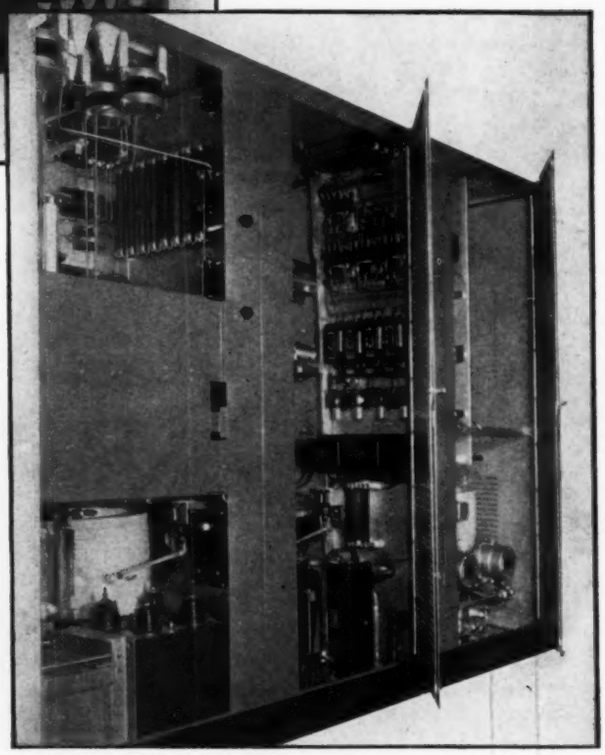


Fig. 3—Rear view with doors open. The three sections are merely for purposes of convenience, as the transmitter is constructed as a single unit

Since modern short-wave stations operate on several frequencies during the day (present W2XE frequencies are 6120, 11830, 15270, 17760, 21520), provision for a number of crystals is necessary. Four positions are provided, so that four crystals may be kept up to temperature and ready for instant use. Each of the four positions has an indicator light associated with it for showing operation of the heater element. Selector switches are so arranged that two crystals may be permanently connected in the circuit. This provides a set-up, such that instantaneous changeover between any two pre-selected frequencies can be accomplished. The crystal units utilized are the small plug-in interchangeable type. Each unit contains a low temperature coefficient crystal, a heater element, and a thermostat of the glass-enclosed bimetallic type. The crystal units are capable of keeping the total frequency deviation of the transmitter within .01 of one per cent. Since they are inexpensive, uncritical and rugged, any desired number of them may be kept on hand and substituted at will in the four positions.

Tube Line-Up

The crystal heater units are used in conjunction with an oscillator stage employing a 42 with an untuned plate circuit. The crystal frequency is from three to five megacycles, depending on the output frequency in use. The oscillator is followed by a buffer stage employing a 802 operating at the crystal frequency. This is followed by a first doubler-stage using an 803, and a second doubler-stage using a pair of 803's. The latter drives an intermediate power amplifier which uses four 803's and operates at the output frequency. These in turn drive the power amplifier which consists of a pair of 207's in push-pull, feeding an output circuit designed to match a 500-ohm line.

The audio portion of the transmitter consists of two audio amplifier stages and the modulator stage. All three are push-pull connected

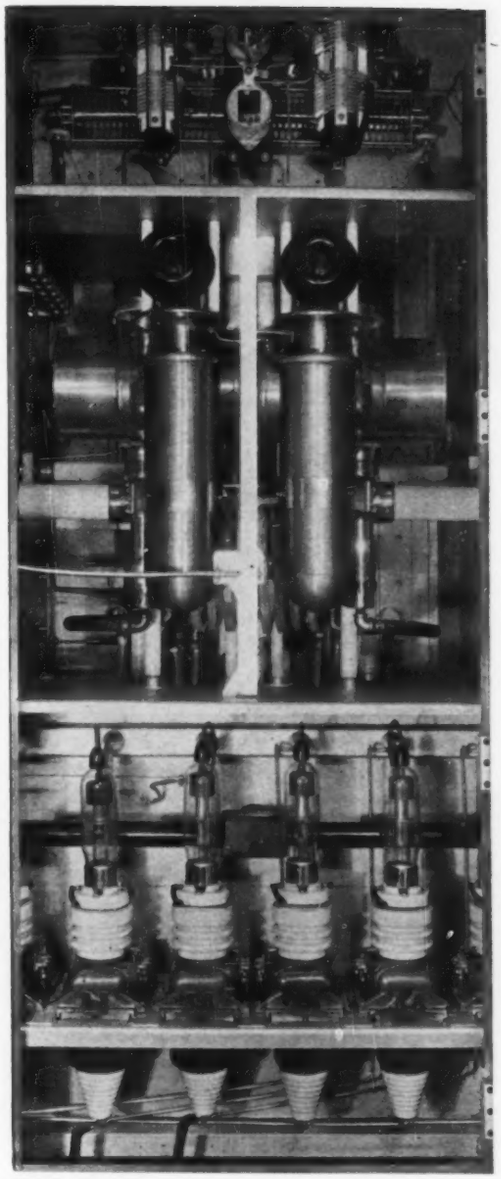


Fig. 7—Front view of the power amplifier unit. The large "bullets" in the foreground are the neutralizing condensers

ately accessible through the front doors of the unit. All other components are mounted on the back of these panels or on shelves attached thereto so that they are immediately available when the rear doors are open. It is interesting to note that in this new transmitter the "walk-in" idea has been carried to the ultimate end, i.e., full length doors are provided in front and rear. This arrangement is made possible by providing small vertical panels (between the main front doors) on which are located all tuning controls. These are ordinarily hidden by small doors which, unlike the main doors, are not interlocked.

In addition to the major constructional details there are many minor features of interest which it is hardly possible to mention in a short description. Close inspection of the several interior views will reveal many of these. For instance, in Fig. 6 is shown the front view of the exciter unit. In this may be seen the arrangement of alternative tank circuits used to obtain rapid frequency-changeover in the low-power stages. At the right of this view, behind the vertical door is part of the control circuit components of the transmitter. To the right of this door (not shown) are the magnetic circuit-breaker, the gravity-operated high-voltage switch, the porcelain cooling reels, and the water-flow indicators. In Fig. 7 is shown a close-up view of the power amplifier section. Directly in front will be seen the bullet-like neutralizing condensers which are provided with micrometric controls. Just behind these are the tubes, water-cooled tank coil and enclosed-type tank condenser. Above may be seen the antenna coupling circuits, and below, four of the twelve tubes which compose the high-voltage rectifier. In general these glimpses give a good idea of the advanced and finished design of this new short-wave broadcast transmitter.

Broadcast Quality

Such factors as crowded allocations, dependence on sky-wave transmission, and the prevalence of the DX reception idea, place limits on the fidelity which it is possible to obtain at present in short-wave broadcasting. However, good engineering practice requires that the designer look ahead over the period of years extending to likely obsolescence of the transmitter, and provide for meeting any standards likely to be set up by changing conditions during that period. From this viewpoint, nothing less than the minimum standards as defined for high-fidelity transmission can be tolerated in a modern broadcasting transmitter, whether for short-wave, or broadcast band operation.

The performance characteristics of the W2XE transmitter not only provide for the ordinary standards of high fidelity transmission, but also for that safety factor necessary to insure such performance in day-to-day operation. Generally speaking, the specifications are the equivalent of those of the more recent broadcast transmitters. The frequency response is within 1 db. from 100 to 5000 cycles, and within 1.5 db. from 30 to 10,000 cycles. The audio frequency distortion is less than 4% r-m-s for the range of 50 to 7500 cycles, from zero to 100% modulation. The unweighted background noise level is 45 db. down. This latter is not quite the equal of the new broadcast transmitters, but is in all probability, fully as great as can be utilized in short-wave broadcasting.

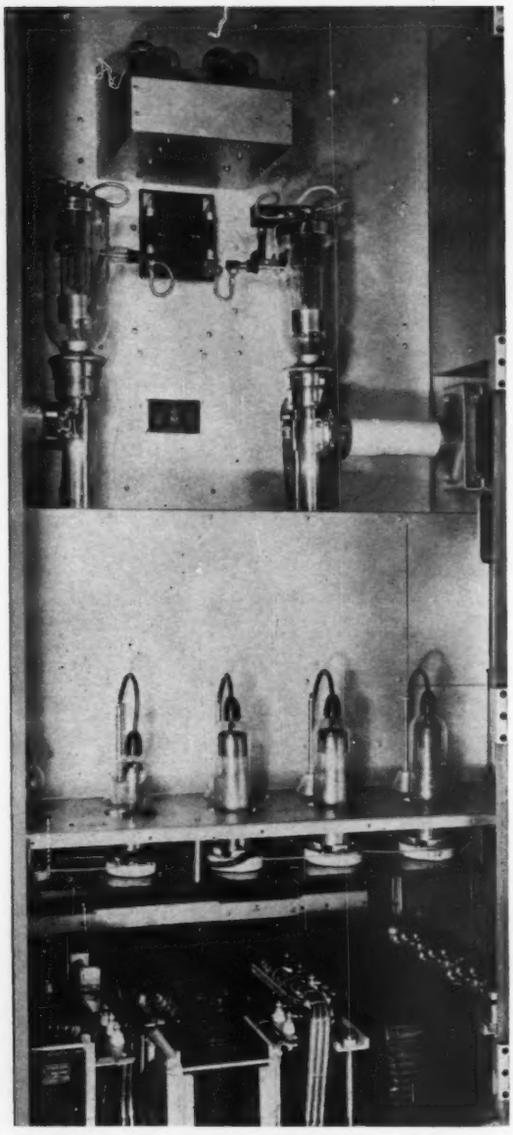


Fig. 5—Front view of the modulator unit. Audio tubes are on the shelf at the top; low power rectifiers may be seen at the bottom

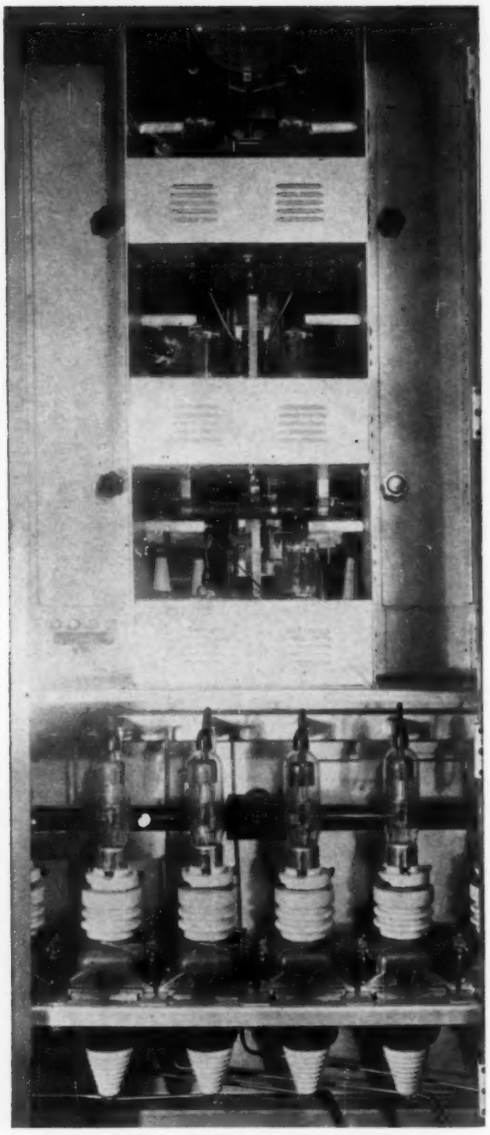


Fig. 6—Front view of the exciter unit. The two small doors on each side of this assembly may also be opened to provide additional accessibility

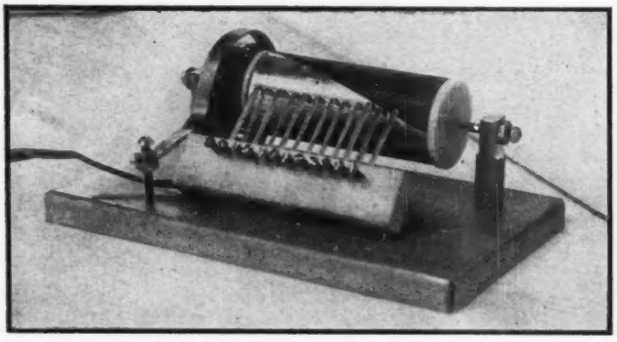
put varying from 10 kw at 6 Mc) to 6 kw at 20 Mc) and to change the tuning circuit of the oscilliscope which is used as a modulation indicator. Still another change is accomplished in the output circuit, this being so arranged as to connect to either of two alternative transmission lines, which may in turn be connected to antennas designed for the corresponding operating frequencies. All of these changes are accomplished by mechanical switches operated by solenoids so that closing the switch in the solenoid exciting circuit provides the complete operation.

The construction of the unit is unique for this power and type of transmitter. Not only is it much smaller in dimensions, but the mechanical design and appearance are quite different from any previous designs. With the exception of the cooling system, plate transformer, modulation transformer and choke, and minor items, it is entirely self-contained. The transmitter housing proper is approximately 9½ ft. long, 7 ft. high, and 4 ft. deep. Unlike any previous transmitters of comparable power, it is a single unit, built, shipped and installed as such. Thus, although it is divided into three sections, these are chiefly for purposes of shielding and convenience, and are not separable.

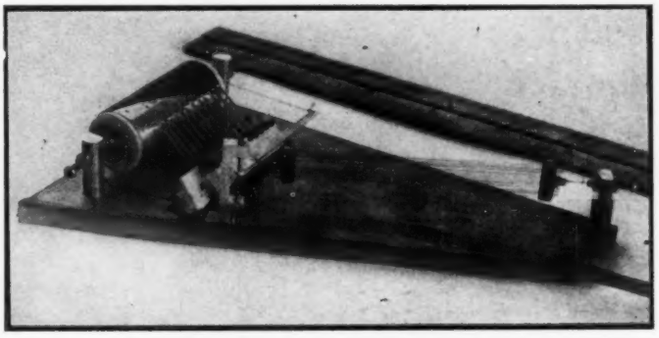
The general aspects of the design and construction will be evident from the several views which are shown. Externally the transmitter is a single unit marking a new high in attractiveness of design. Internally it is divided into three sections, housing (from left to right) modulator, exciter, and power amplifier. The rectifiers extend across the bottom of all three units. The method of mounting components is similar to the vertical chassis-type construction developed for a new line of broadcast transmitters. All tubes are mounted on the front of vertical panels so that they are immedi-

Radio in the Sky

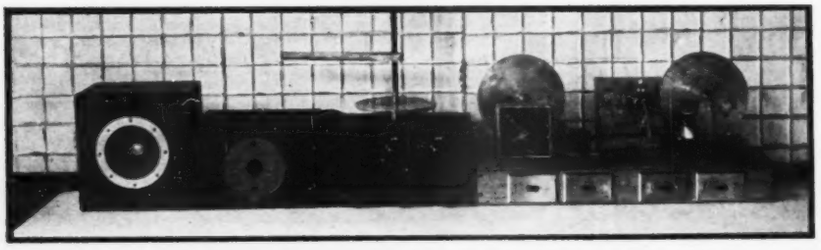
Most ingenious are the radio transmitters carried by balloons to investigate meterological conditions in the upper atmosphere. Photos on this page from University of Minnesota and on opposite page from the Blue Hills Observatory, Harvard University



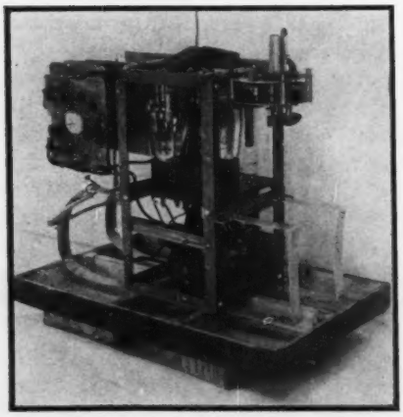
Thermometer unit using bimetal coil which causes drum to rotate similar to the action of the hygrometer unit

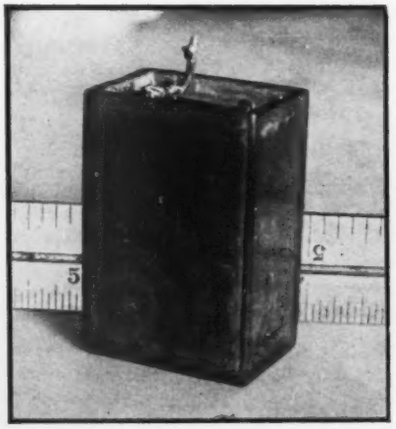


Human hair hygrometer. Change in length revolves drum providing contact between silver inlay and contacts

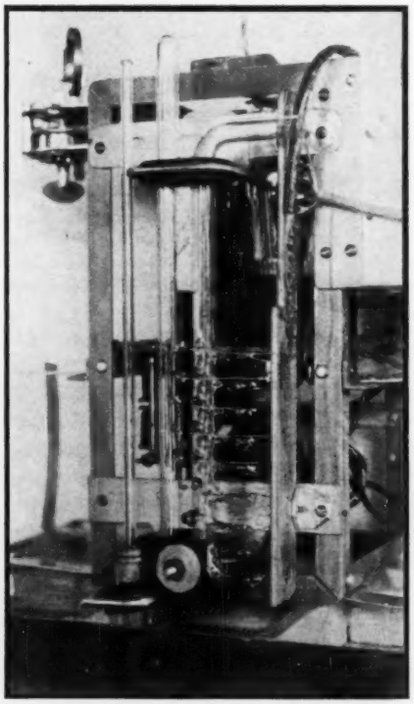


Receiver with (left to right) loud speaker, amplifier, directive receiver and tape recorder—the latter really not being necessary



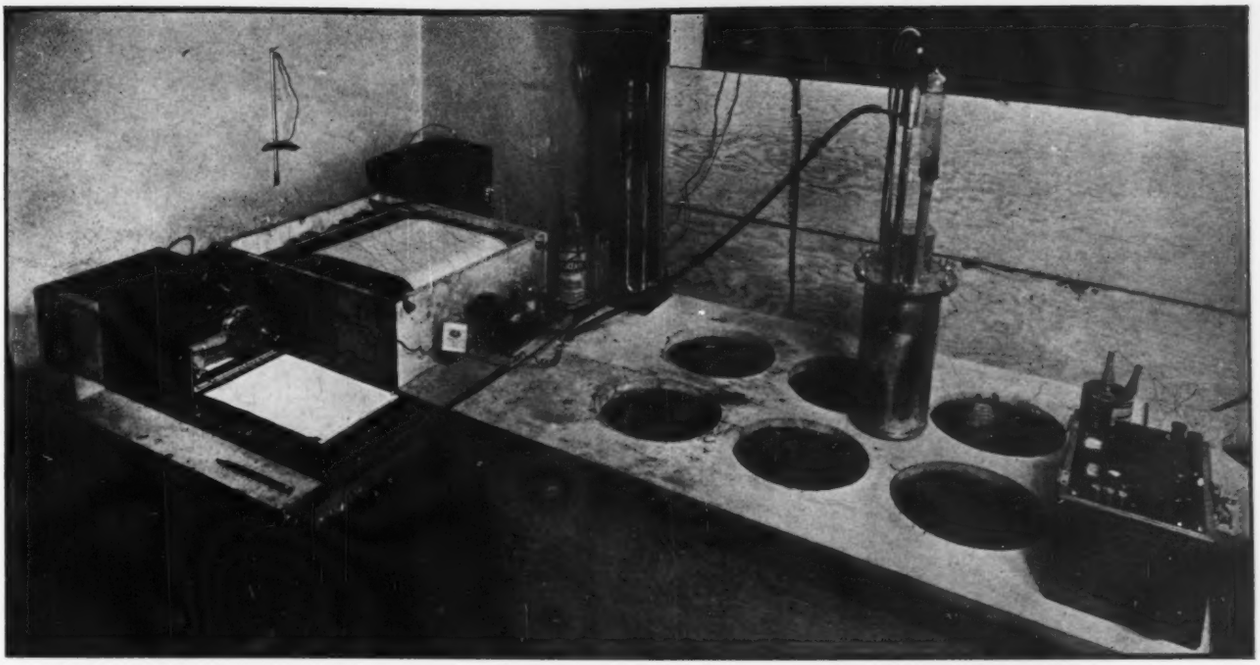


Transmitter, battery powered, 62,000 kc, modulated at 400 cycles. It uses push-pull 30 tubes. Without batteries, weighs 1 lb. 14 oz. At right is storage battery to light filaments. Weighs 5 oz. will operate transmitter 7 hours. Plate supply is 135 volts of Burgess batteries

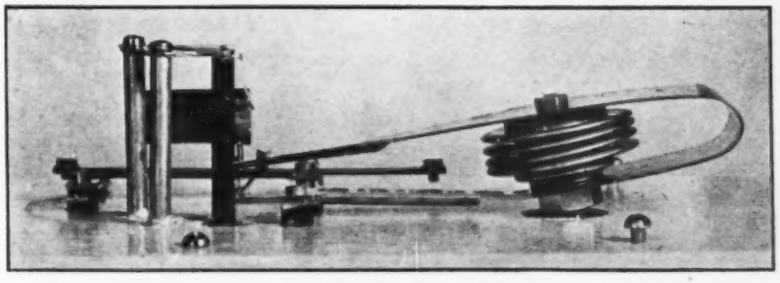


Minimum and recording barometers. Right is glass U tube with tungsten points in wall. Will indicate 22 different altitude readings

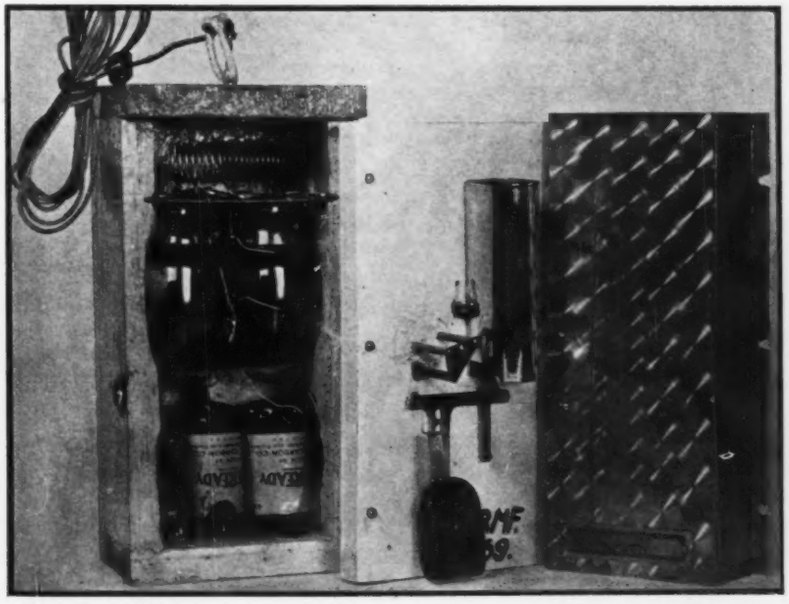
UNIVERSITY OF MINNESOTA



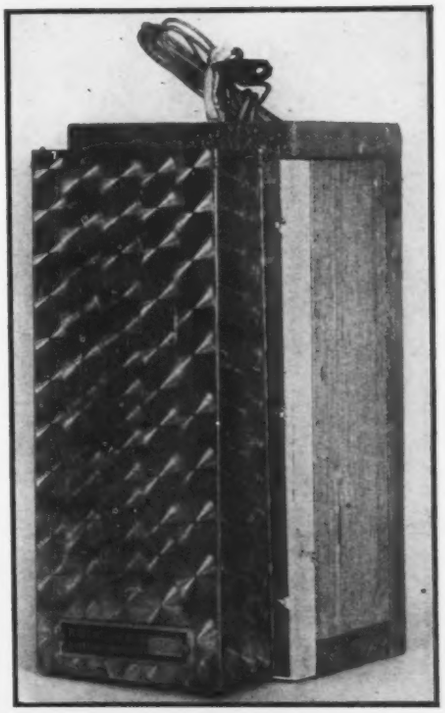
Calibration equipment. Instrument is inside cylinder in which pressure is reduced, then put into various holes in which are different temperatures

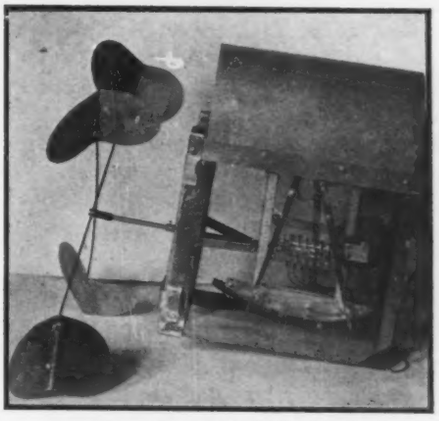


Blue-Hill modified Olland-type meterograph. Gold wire, spiral, turned by clock, twice a minute makes contact with 4 arms, one fixed, 3 moved by bimetal thermometer, single hair hydrometer, aneroid barometer. Clock and radio are in balsa wood to protect them from extreme cold



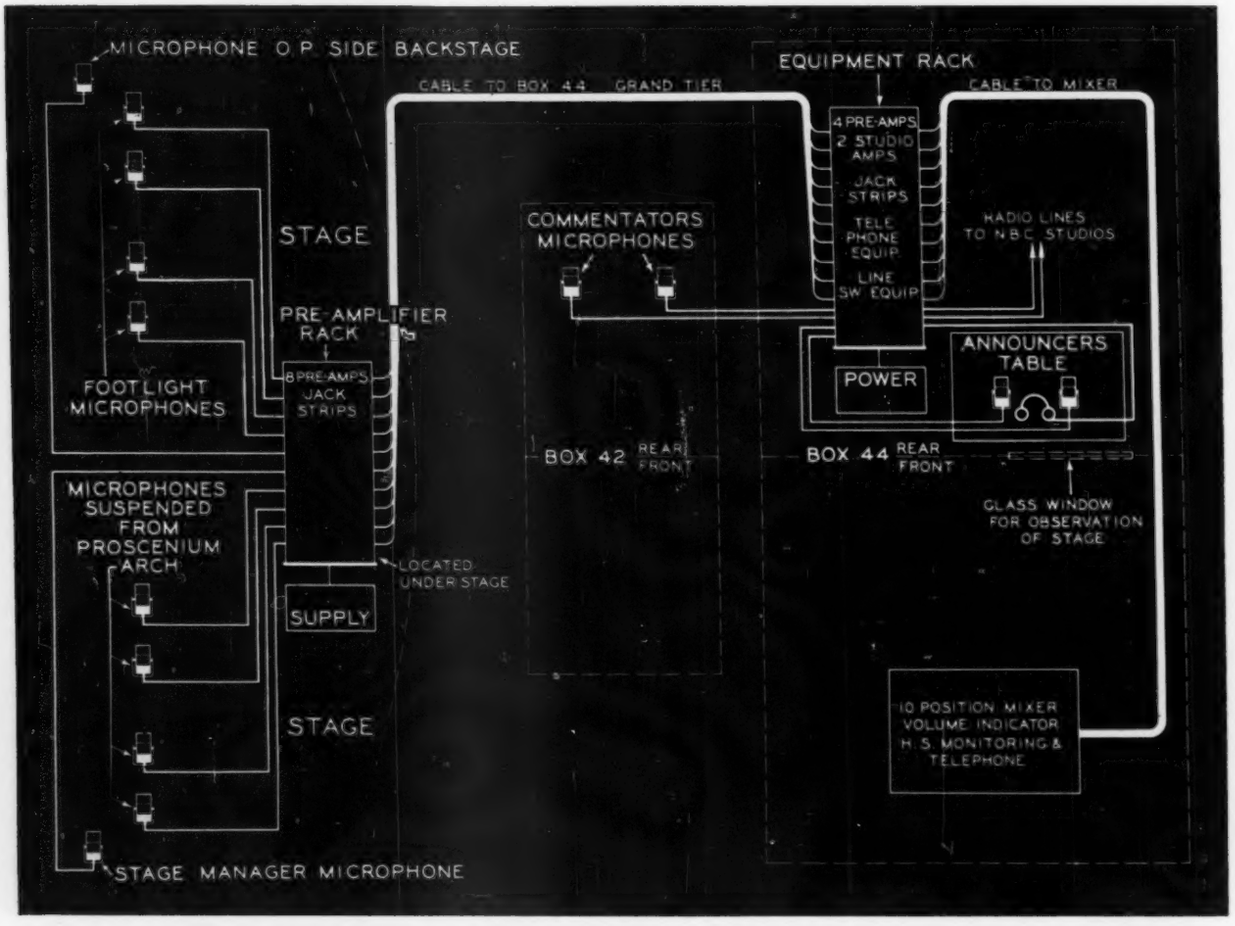
Complete transmitter. Two 45 volt B batteries, one 4.5 volt A battery. Snap on left of box connects A battery just before releasing balloon. Above, right, transmitter box closed, ready to go aloft. The metallic shield protects the instruments





Early (1926) Moltchanoff radio-meterograph used in Russia. Air moving past instrument turns fan, operates switching

Metropolitan Opera



Complete layout of microphones and control equipment in use at the Metropolitan Opera House, New York City for NBC broadcasts

SATURDAY matinee performances at the Metropolitan Opera House have become a radio institution. Since Christmas Eve, 1931, with the broadcast of "Hansel and Gretel," no week during the season at the historic American center of grand opera has gone by without its complete performance given over one or the other of the National Broadcasting Company's two networks. Some of the greatest singers of our times—Flagstad, Melchior, Ponselle, Martinelli, Pons, Gigli, Schorr, Tibbett, Scotti, Jeritza, Bori, to name only a few—have sung for an audience that extends from coast to coast and beyond to Hawaii, and by short-wave to South America and Europe.

Naturally, any such broadcast—three hours of leading singers, chorus and orchestra united in a single presentation—would come to have a technique of its own. This is particularly true of the Metropolitan broadcasts, since these are, from an operation viewpoint, field broadcasts. Radio, in other words, must make the best of any adverse circumstances, and there are many at the Metropolitan.

To begin with, the opera is given for the audience in the great auditorium; no concessions are made to broadcasting, beyond allowing NBC equipment to be installed and the opera itself broadcast Saturday afternoons. In fact, none of the apparatus must be in evidence so that either performers or members of the audience be aware that the performance is being broadcast. Next, the elements of opera, which in the studio would be carefully rearranged to permit best microphone pick-up, follow in the strict tradition of the stage. Finally, the acoustics at the Metropolitan, although satisfactory for the present audience, are far from ideal for radio.

In solving the numerous problems raised at the Metropolitan, NBC engineers have devised one of the most flexible systems of microphone pick-up in the world. During an actual performance the engineer, sitting in the famous Box 44 of the Grand Tier, has at his command ten microphones placed at the most strategic of the available pick-up points. And it is by the use of these microphones in different combina-

on the Air

Since 1931, the Metropolitan has been broadcast by NBC. A description of the apparatus; the technique; the liaison between musicians and broadcast pickup engineers.

Herbert Liversidge signals "chorus is coming in soon." The number of fingers showing indicates the nearness of the chorus musically

Charles Grey, at faders, interprets Mr. Liversidge's signals at the 10-stage mixer. This is Box 44 at the Met"

tions that he puts grand opera on the air. In short, the engineer acts as a second conductor, determining the relative volume of each of the elements of opera and blending them into a harmonious whole.

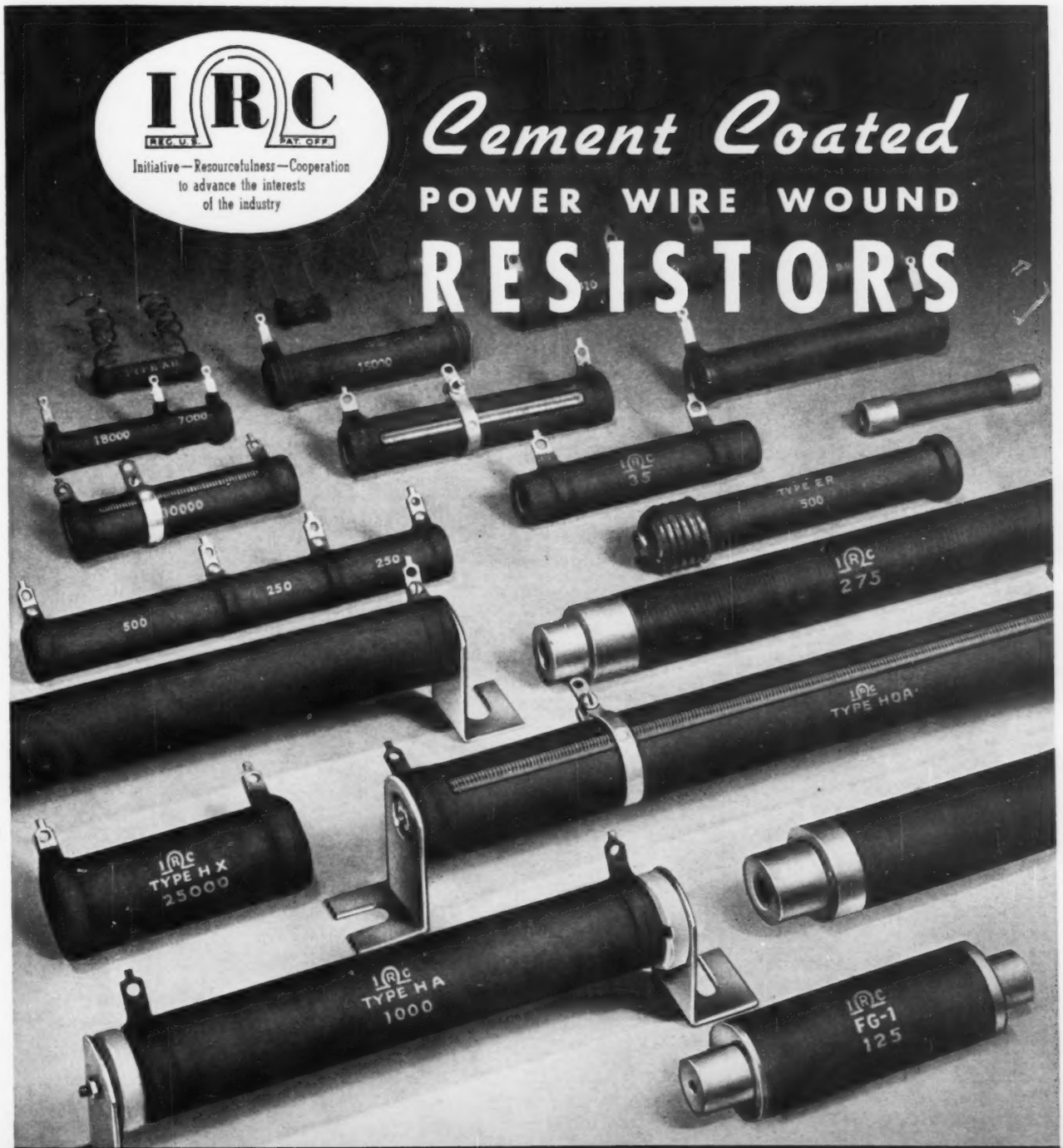
Of the ten microphones, seven are of the inductor type. Four are placed, in pairs, in the footlights at either side of the stage. One of each pair is tilted upward to receive sounds from the stage sets, the ceiling, etc.; the other is directed at the floor so that it registers sound intensity at a point some two feet in front of the instrument. This arrangement provides clear and sharp recording of performers' voices, regardless of their positions on the stage. Two other inductor microphones, for occasional use, are placed in the wings at either side of the stage.

Pick-up facilities are rounded out by four microphones suspended from the proscenium arch, three being of the uni-directional ribbon type. Two of these provide orchestra pick-up; one is hung slightly to the left of center of the orchestra, the other about five feet further to the left, or directly over the string section. The former is used when the orchestration is evenly balanced as between strings and brasses. If, however, brasses predominate, the microphone over the string section is used to maintain the balance. These two microphones are also adjustable as to height, varying from thirty-five to forty-five feet above the orchestra. The level chosen varies inversely with the level of the orchestra pit. When the orchestra is lowered to diminish the volume for the present audience, the effect is to intensify the directional characteristics of the sound. It is as if the orchestra were playing in a well above which the microphone is placed. To counterbalance this effect the microphone is raised. The third uni-directional microphone is often used to pick up choruses over the heads of the ballet. The fourth instrument, an inductor microphone, records audience applause.

Cables joining microphone receptacles and preamplifiers understage are made up of individually shielded pairs of copper braid, encased in lead sheaths. These cables,

[*Continued on page* 37]

UNEQUALLED DEPENDABILITY
UNDER THE MOST SEVERE CONDITIONS



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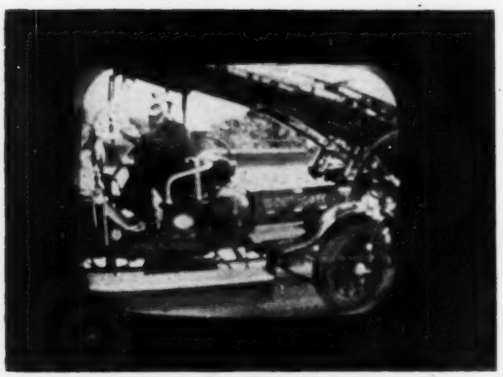
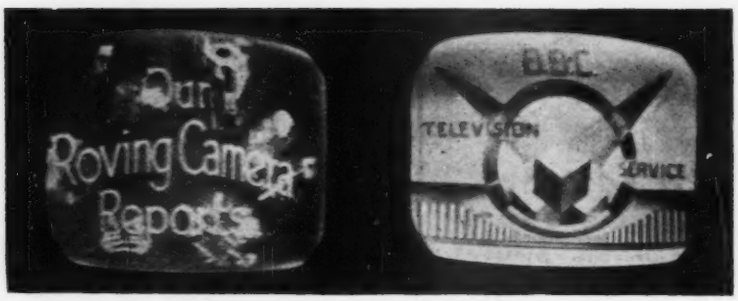
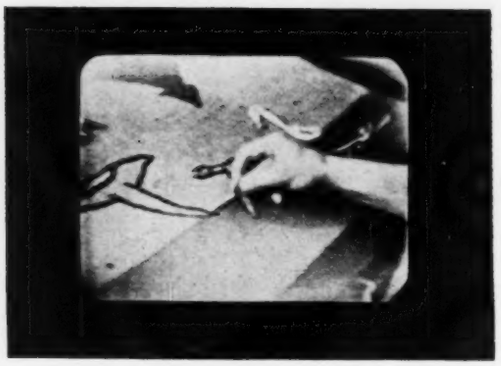
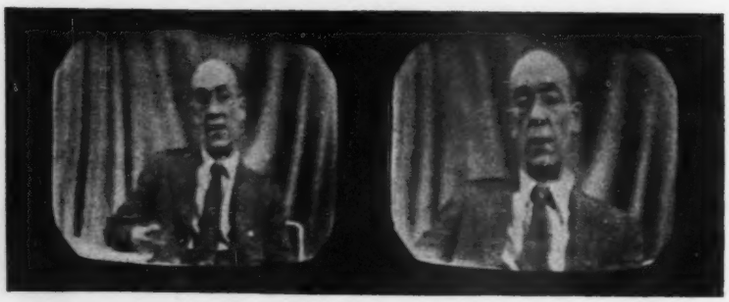








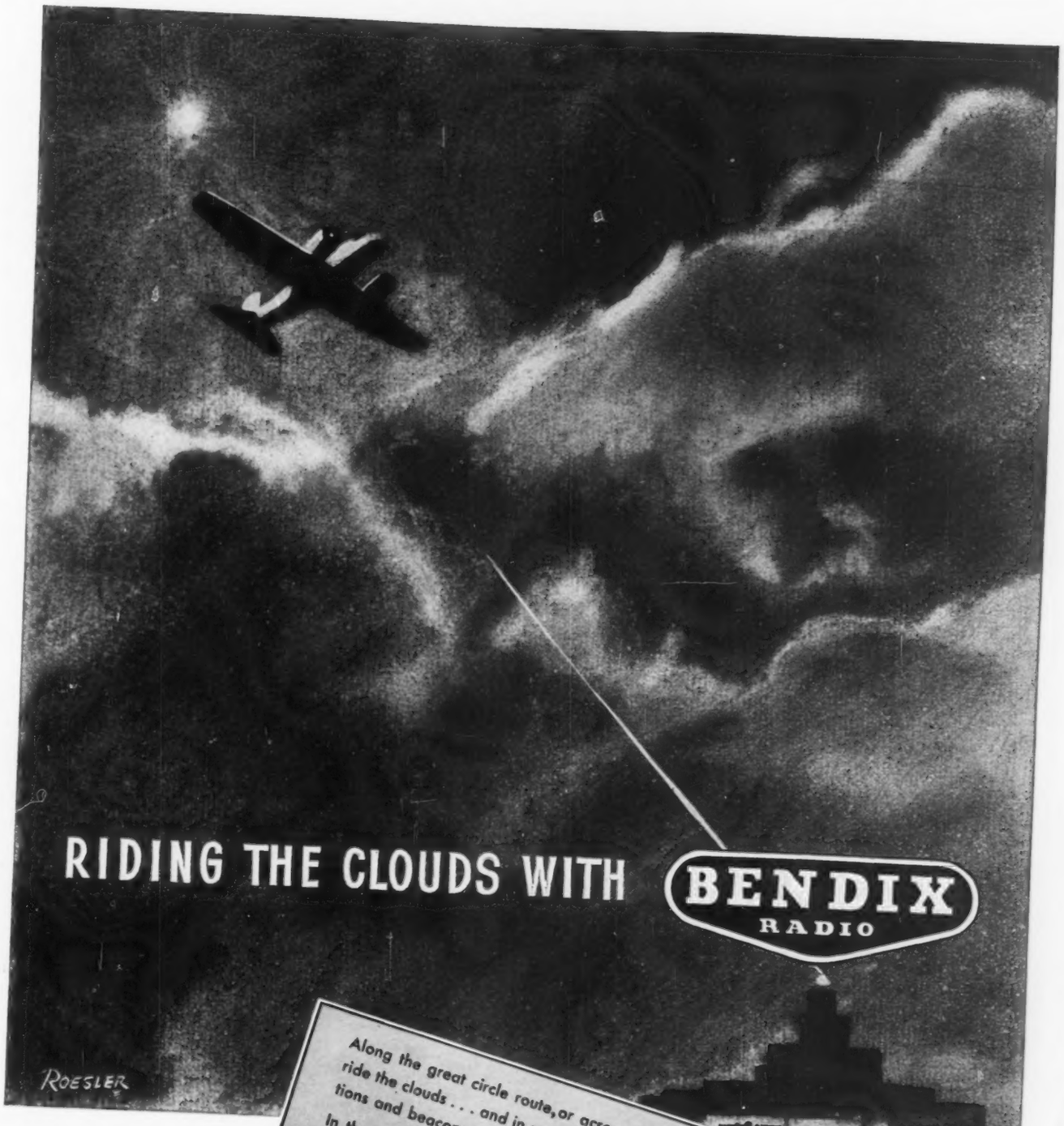
See for Yourself

Concerning your article "Television in Gt. Britain" (October, 1937) I do not think that the reproduced photograph of a Wimbledon relay race does justice to the results generally obtained. I admit that the subject is of greater interest than a studio item, and I agree that it is not an easy one to photograph.

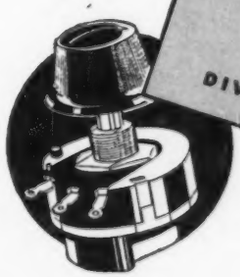
In the hope that they will interest I enclose a few rough prints of snaps taken at my location (70 miles from the transmitter, low ground level) and some taken at 40 miles by a Mr. Westhead from a standard "Cossor" receiver.

The receiver used for my own snaps was that designed for the home constructor and described in "Television & Short Wave World".

S. WEST
15, *St. Matthews Street*
IPSWICH
Suffolk, England



Along the great circle route, or across uncharted jungles, Bendix equipped ships ride the clouds . . . and in more peaceful and prosaic pursuits Bendix ground stations and beacons will make positive contact with their winged companions aloft. In these various installations CENTRALAB Volume Controls, Fixed Resistors, and Switches play a dependable part.



Centralab

DIVISION OF GLOBE-UNION INC., MILWAUKEE, WIS.

Allocations in the U-H-F Spectrum

Channels between 30 and 300 megacycles have been assigned to definite services by the FCC, as a result of the hearings held in June, 1936. This listing is supplementary to the general allocation chart published in *Electronics*, September 1934.

30.02–30.50	G(13)	33.50	P	37.46	F	66.00–72.00	T(1)	132.40	SV	139.82	AV
30.54	CSH	33.54	GMP	37.50	P	72.04–77.96	G(75)	132.54	CSH	139.96	EX
30.58	P	33.58	PR	37.54	EX	78.00–90.00	T(2)	132.68	EX	140.10	MF
30.62	GMP	33.62	SV	37.58	CSH	90.04–95.96	G(75)	132.82	P	140.24	F
30.66	EX	33.66	MF	37.62	RB	96.00–108.00	T(2)	132.96–133.10	B(2)	140.38	EM
30.70	P	33.70	G	37.66	IS	108.04–111.96	G(50)	133.24	F	140.52	AV
30.74	SV	33.74	RB	37.70	G	112.00–118.00	AM	133.38	SV	140.66	B
30.78	F	33.78	P	37.74	MF	118.06–126.42	G(71)	133.52	P	140.80	SV
30.82	RB	33.82	EM	37.78	P	126.54	ATC	133.66	EM	140.94	P
30.86	PR	33.86	F	37.82	EM	126.66–126.90	G(3)	133.80	F	141.08	F
30.90	G	33.90	P	37.86	AV	127.02	ATC	133.94	AV	141.22	AV
30.94	FO	33.94	F	37.90	P	127.14–127.38	G(3)	134.08	B	141.36	EX
30.98	P	33.98	PR	37.94	CSH	127.50	ATC	134.22	PR	141.50	F
31.02	SV	34.02–34.98	G(25)	37.98	RB	127.62–127.86	G(3)	134.36	EX	141.64	EM
31.06	GMP	35.02	RB	38.02–38.98	G(25)	127.98	ATC	134.50	P	141.78	AV
31.10	P	35.06	EX	39.02	PR	128.10–128.34	G(3)	134.64	F	141.92	SV
31.14	EX	35.10	P	39.06	AV	128.46	ATC	134.78–134.92	B(2)	142.06–143.88	B(14)
31.18	F	35.14	EM	39.10	P	128.58–128.82	G(3)	135.06	P	144.08–155.88	G(80)
31.22	RB	35.18	PR	39.14	SV	128.94	ATC	135.20	AV	156.00–168.00	T(2)
31.26	CSH	35.22	P	39.18	P	129.06–129.18	GB	135.34	SV	168.04–179.86	G(68)
31.30	G	35.26	RB	39.22	CSH	129.30	ATC	135.48	CSH	180.00–192.00	T(2)
31.34	FO	35.30	G	39.26	RB	129.42–129.66	GB	135.62	SV	192.14–203.94	G(61)
31.38	F	35.34	CSH	39.30	G	129.78	ATC	135.76	B	204.00–216.00	T(2)
31.42	EM	35.38	F	39.34	EM	129.90–130.02	GB	135.90	PR	216.11–223.81	G(36)
31.46	F	35.42	FO	39.38	P	130.30	ATC	136.04	F	224.00–230.00	AM
31.50	P	35.46	SV	39.42	FO	130.44–130.72	GB	136.18	P	230.12–233.72	G(16)
31.54	SV	35.50	P	39.46	EX	130.86	ATC	136.32	AV	234.00–246.00	T(2)
31.58	FO	35.54	GMP	39.50	P	131.00–131.28	GB	136.46	EM	246.12–257.76	G(46)
31.62	RB	35.58	AV	39.54	SV	131.42	ATC	136.60	F	258.00–270.00	T(2)
31.66	CSH	35.62	RB	39 58	CSH	131.56–131.70	GB	136.74–136.88	B(2)	271.14–281.78	G(39)
31.70	G	35.66	CSH	39.62	RB	131.84	ATC	137.02	AV	282.00–294.00	T(2)
31.74	EM	35.70	G	39.66	EM	131.98	GB	137.16	CSH	294.15–299.85	G(20)
31.78	P	35.74	FO	39.70	G	132.12	AV	137.30	P		
31.82	FO	35.78	P	39.74	FO	132.26	B	137.44	SV		
31.86	F	35.82	RB	39.78	P			137.58	MF		
31.90	P	35.86	IS	39.82	RB			137.72	F		
31.94	F	35.90	P	39.86	EM			137.86	SV		
31.98	PR	35.94	FO	39.90	P			138.00	PR		
32.20–32.98	G(25)	35.98	PR	39.94	FO			138.14	EX		
33.02	PR	36.02–36.98	G(25)	39.98	PR			138.28	AV		
33.06	F	37.02	RB	40.02–40.98	G(25)			138.42	P		
33.10	P	37.06	F	41.02–43.98	B(75)			138.56–138.70	B(2)		
33.14	F	37.10	P	44.00–56.00	T(2)			138.84	SV		
33.18	EM	37.14	SV	56.00–60.00	AM			138.98	AV		
33.22	P	37.18	EM	60.02–65.98	G(150)			139.12	P		
33.26	PR	37.22	P					139.26	EM		
33.30	G	37.26	CSH					139.40	F		
33.34	EX	37.30	G					139.54	SV		
33.38	RB	37.34	RB					139.68	PR		
33.42	AV	37.38	P								
33.46	SV	37.42	PR								

SYMBOLS

AM—Amateur
ATC—Airport Traffic Control
AV—Aviation
B—Broadcast
CSH—Coastal and Ship Harbor
EM—Special emergency
EX—Experimental
F—Fixed
FO—Forestry
G—Government
GB—Guard band
GMP—Geophysical and motion pictures
IS—Intership
MF—Marine Fire
P—Police
PR—Mobile Press
RB—Relay broadcast
SV—Special services
T—Television

Numbers in parentheses indicate number of channels

ELECTRONICS REFERENCE SHEET

Opera on the Air

(*Continued from page 31*)

permanently installed in duplicate, also extend through the mixer. Also understage is an equipment rack mounting, besides the preamplifiers, the associated power and control equipment. A cabinet for storing spare microphones is located nearby.

Broadcasting activities center in the adjoining boxes 42 and 44 of the Grand Tier, at the rear of the house. The equipment rack, in the foyer of Box 44, houses duplicate high-gain studio amplifiers, four preamplifiers for the announcer's and commentator's microphones, line switching keys, telephone apparatus and jacks for terminating all circuits. This rack is permanently installed in one corner of the foyer and, when not in use, is covered by a red plush curtain in harmony with the Metropolitan's scheme of decoration. Also in the foyer of Box 44 is the announcer's table, removed from the noises of the audience. Milton Cross, the announcer, is provided with two microphones of standard studio (ribbon velocity) type.

The foyer of Box 42 is used as a miniature broadcasting studio during intermissions. Here it is that commentators and guests make their appearances. The equipment consists of standard studio type microphones and "Stand By" and "On the Air" lights for warning announcer and guests. On several occasions a miniature piano has been moved into this room for the use of a commentator in illustrating remarks on the day's opera.

The nerve center of the Metropolitan broadcasts is at the front of Box 44. Here all the equipment heads up in a ten-position mixer, specially designed and built for its present use. Each microphone of the stage installation is controlled by a "fader," the controls on the mixer panel being arranged in two pyramids at either side of the instrument to correspond to the position of the stage microphones. The only illumination permitted is a small cowl lamp to light the volume indicator.

The positions of engineer and announcer reverse the usual order. In the radio studio the announcer, in the presence of a controlled audience, needs no protection from audience noises. At the Metropolitan, however, the patrons move about and raise a hum of conversation during intermissions, so the announcer is shielded from the audience in the foyer of Box 44. In studio practice the engineer is located in the control booth, separated from the main studio by a thick plate glass. At the Metropolitan, on the other hand, the stage must be plainly visible so the engineer sits at the front of the box.

This, then, is the apparatus. A simple description of it clearly indicates that the work of broadcasting Metropolitan Opera demands more than a knowledge of circuits. A background of the operatic art and the technique of the stage are indispensable. NBC engineer Charles C. Grey is the veteran of grand opera broadcasting. His experience dates back to 1929 when NBC began broadcasting the performances of the Chicago Civic Opera. Two years later, when the Metropolitan series began, Grey was brought to New York. Eight years of experience have given him familiarity with the scores of most of the operas in the Metropolitan repertory.

Obviously, however, no man could be so completely acquainted with all of the details of all of the operas broadcast as not to require assistance from the score. And since the engineer must keep his eyes on the stage during a performance, a production man is needed. This man during the last season was Herbert E. Liversidge, a graduate of New England Conservatory and a singer of considerable experience. During the broadcast he sits beside the engineer with the score of the day's opera in an illuminated rack before him. Communication is maintained between the two by an elaborate and ingenious set of hand signals. A clenched fist raised, for example, indicates an orchestra crescendo; dropped, it means a diminuendo. Other signals tell of impending entrances, cues, stage action, and so on.

The NBC staff at the Metropolitan is rounded out by announcer Milton Cross and an engineer in the foyer of Box 44, a commentator and an engineer in the foyer of Box 42, an extra engineer for emergencies and another production man who might be described as a scout, in the wings of the stage. This last man must be thoroughly acquainted with Metropolitan backstage routine and also familiar with the half-dozen languages used by members of the Metropolitan stac. The information he receives is telephoned to the men in Box 44.

The work of broadcasting an opera performance begins several hours before the curtain rises. All apparatus for the two boxes, except that mounted on the rack, must be taken from storage, set up and checked. Ten minutes before two o'clock everything must be in order and final tests are made throughout the system as far as Radio City. Announcer Cross then opens the broadcast from the foyer of Box 44 with a description of the first act. Out of the corner of his eye he notices that the light at the front of the box is snapped off and he announces that "the house lights are dimming and in just a moment our conductor will appear in the orchestra pit." This information, of course, was indicated in the switching off of the light since Cross is not in a position to be aware of what is happening in the auditorium. The scout in the wings has warned the staff that the conductor has passed on his way to the pit.

Immediately the center of activities switches to the front of Box 44 where Grey and Liversidge take up the task of presenting what Cross has described. Here the wisdom of arranging the fader controls in pyramids at either side of the mixer is demonstrated, for Grey must work in the darkened auditorium. The conductor raises his baton, the overture begins and Grey, apprised of what comes next by Liversidge's hand signals, begins manipulating the faders singly and in combinations and listeners in Honolulu, Montevideo, San Francisco, Uganda and London settle down for another performance at one of the world's great centers of the operatic art.

TUBES AT WORK

TUBE applications for this month include u-h-f oscillator, voltage regulator, keying transmitters with tubes, a high resistance bridge.

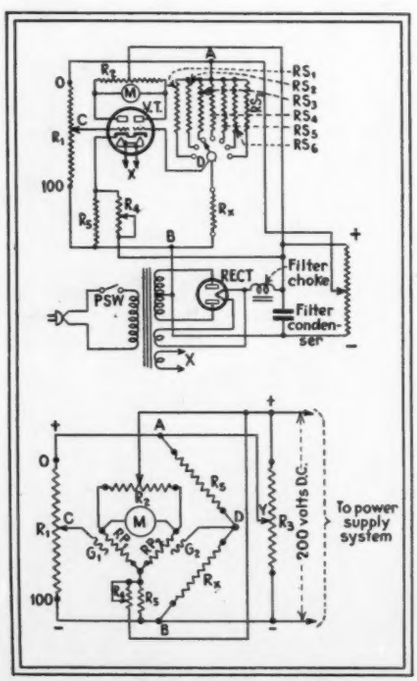
Vacuum Tube Resistance Bridge

A VACUUM TUBE BRIDGE sufficiently sensitive to measure resistances of from less than 100 ohms to more than 200,000 megohms and developed for determining the electrical resistance of chemically treated wood is described by I. I. Davies in *Instruments* for October, under the title "A Wide Range Vacuum Tube Resistance Bridge." The bridge consists of the bridge circuit proper, the bridge balance indicating circuit, and a power supply.

The portions of the slide wire R_1 on either side of the sliding contact point C form two arms of the bridge. Any one of the seven resistors RS_1 to RS_7 which may be selected by means of the switch key form the third arm of the bridge and the unknown resistance is the fourth arm of the bridge and is designated as R_x.

The bridge balance indicator, which is itself a bridge circuit, consists of a double triode vacuum tube, an adjustable resistance R_2 and a zero center low range milliameter, *M*, together with a grid bias in resistance, R_3, and a grid bias adjusting voltage divider, R_4. The power supply for this resistance bridge is similar to that used in many radio receivers and consists of a transformer, double wave rectifier and simple filter.

The complete connection for the bridge as well as a simplified schematic wiring diagram are indicated. With slight modifications of the circuit the bridge can be used as a vacuum tube voltmeter, in which case it is capable of measuring an unusually wide range of voltages without drawing current from the voltage source.



Schematic wiring diagram of high resistance bridge developed for determining resistance of chemically treated wood

50 to 100 Cm. Oscillator Design

BY A. BINNEWEG, JR.

THE DESIGN OF equipment for use below one meter wavelength presents many new considerations. Ordinary tubes will not function at these frequencies, but the 955 Acorn tube will operate about as easily at ¾ meter as the ordinary receiving tubes will function at 2.5 meters. A 75-cm. oscillator is shown in Fig. 1.

This oscillator consists of about 1½ inches of No. 22 wire in both grid and plate leads and a 0.00025 μμfd mica condenser shunted across their ends. Five chokes are essential. Each choke consists of about 40 turns of No. 34 wire spaced ⅛ inch on a ⅛ in. bakelite or hard rubber rod.

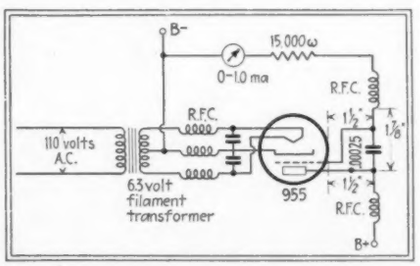


Fig. 1 Wiring diagram of 50-100 cm. oscillator

The Lecher wavemeter of Fig. 2 consists of two wires drawn taut between two supports with a meter stick arranged below the wires, so that the wavelength can be read directly. In using this wavemeter, the coupling coil is bent down to the oscillating circuit until there is loose coupling as indicated by the grid meter. Then the shorting link is moved along the wires until resonance is shown by the grid-meter dip. The distance along the wires between two resonance positions is one-half wavelength. It is necessary to use at least 50 volts on the 955 at 75 cm.

75 Cm. aerials

For coupling to an aerial a thin piece of copper, ¾-in. square, is soldered directly to point *A* on the plate lead in Fig. 2. Another thin copper plate of the same dimensions was soldered to the end of a short length of No. 20 bare wire. This second plate was placed $\frac{1}{16}$ in. from the plate on the plate lead.

The best way to determine the proper antenna length is to attach an aerial which is too long, and then shorten it, a little at a time, until resonance is reached. When the aerial is tuned to the oscillator, the grid current in the oscillator will decrease to a minimum. The complete aerial coupling scheme is shown in Fig. 3. A typical set of values for grid current values and corresponding aerial lengths is given below. Correct antenna length is indicated by minimum grid current.

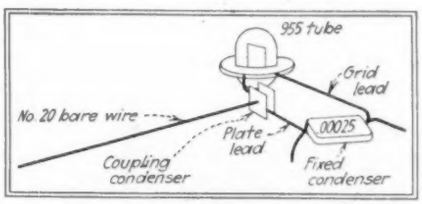


Fig. 2 Coupling the oscillator to the Lecher wire system

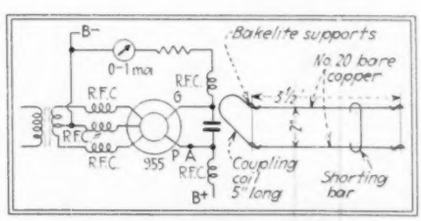


Fig. 3 Complete oscillator and Lecher Wire arrangement

VALUES FOR NO. 20 TINNED COPPER AERIAL WIRE

Length of aerial wire in inches	Grid current in Oscillator, Mils.
13¾	.54
13¼	.20
13	.14
12¾	.08
12½	.06
12¼	.02
12	.04
11¾	.08
11¼	.13
10¾	.28

The aerial length for which the

(*Continued on page* 39)

Tubes at Work

(*Continued from page 36*)

grid current in the oscillator is a minimum is 12¾ inches.

Very short lengths of wire connected to the high voltage parts of the grid and plate of oscillator have surprising effects on the efficiency; for this reason, no superfluous leads or metal lugs or parts should remain connected to the grid and plate leads.

It will be found, in general, that the cathode as well as the heaters of the tube will be at a relatively high r-f potential. This means that chokes have to be used in the heater and cathode leads in order to obtain the best efficiency. Results are also improved by using by-pass condensers connected directly at the tube. The best condensers for this purpose are small midget type 0.00025 μμfd fixed condensers.

• • •

Regulator Maintains Voltage for Motion Picture Printers

By T. A. Reid and E. W. Morris

Industrial Division, Westinghouse Elec. & Mfg. Co., Los Angeles, Calif.

The daily printing of thousands of reels of motion picture film presents one of the most exacting requirements encountered in the application of electrical apparatus. The high speed at which printing is accomplished in the modern printer necessitates the use of a very constant voltage for the lamp from which the light exposes the positive stock, as it, and the developed negative film, passes the light aperture.

After a negative has been developed, it is tested for density and this test determines the light level to be used for making additional prints. Once the light source has been adjusted to a given intensity, no change is permitted while the print is being made. It is this necessity for a constant intensity of the light source that presents the problem. A typical installation may consist of seven to ten printers, each with two 500 watt lamps, all operating from a 10 kw. generator. Each printer is equipped with a rheostat in series with a lamp to establish the proper light level.

A serious change in load occurs when individual printers are turned on or off. Such a change in load materially affects the output voltage of the direct-current generators, even if compound wound. To maintain the constant voltage value which is essential for film printing procedure vibrating types of regulators have been used, but the inherent time lag due to the inertia of

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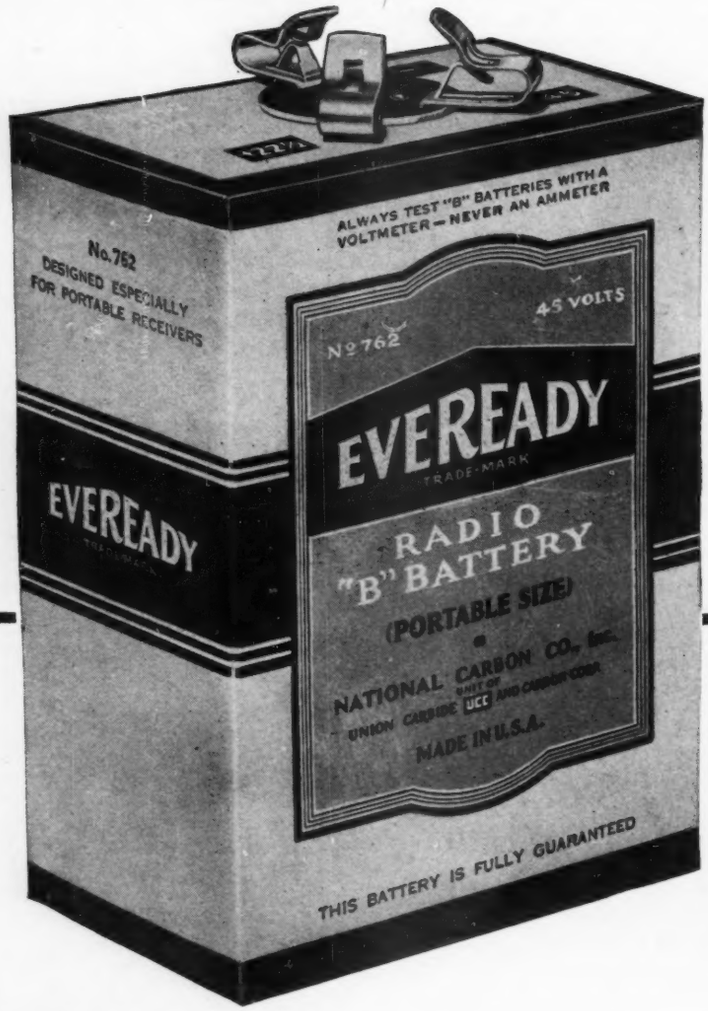

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NOTE: The No. 762 battery equipped with screw terminals and insulated knurl nuts is still available as No. 762-S.

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moving parts and the fact that the low sensitivity of such equipment required a considerable change in machine voltage before the regulator functioned, has caused them to be abandoned.

Voltage changes of less than ½ volt plus or minus from normal were demanded, without hunting. These exacting requirements lead to the development of the electronic voltage regulator for direct-current generators. Upon applying it to this type of work in a number of different film laboratories, it was found that the required tolerances could readily be maintained or bettered.

The electronic regulator shown in the figure is instantaneous in its response to voltage changes at the terminals of the generator to which it is

Compact electronic regulator operating on less than one microwatt of control energy

applied. It is designed to operate on a control energy of less than one microwatt, which may be contrasted to a control energy requirement of approximately 100 voltamperes for the operation of most mechanical types of regulators. Quick response is obtained through the use of electronic tubes and the elimination of friction and inertia inherent with all mechanical regulators. The operation of an electronic regulator is simple. A slight voltage change detected at the terminals of the generator is applied to the grid of an amplifier tube, and a proportional correction immediately applied to the field current of the generator.

Two arrangements were developed, one in which the correction is applied directly to the field of the generators rated from 2 to 10 kw., and the other where the correction is applied to the exciter of a separately excited generator, as indicated in the figure. Where the separate exciter is used, capacities up to approximately 300 kw. can be regulated with this device.

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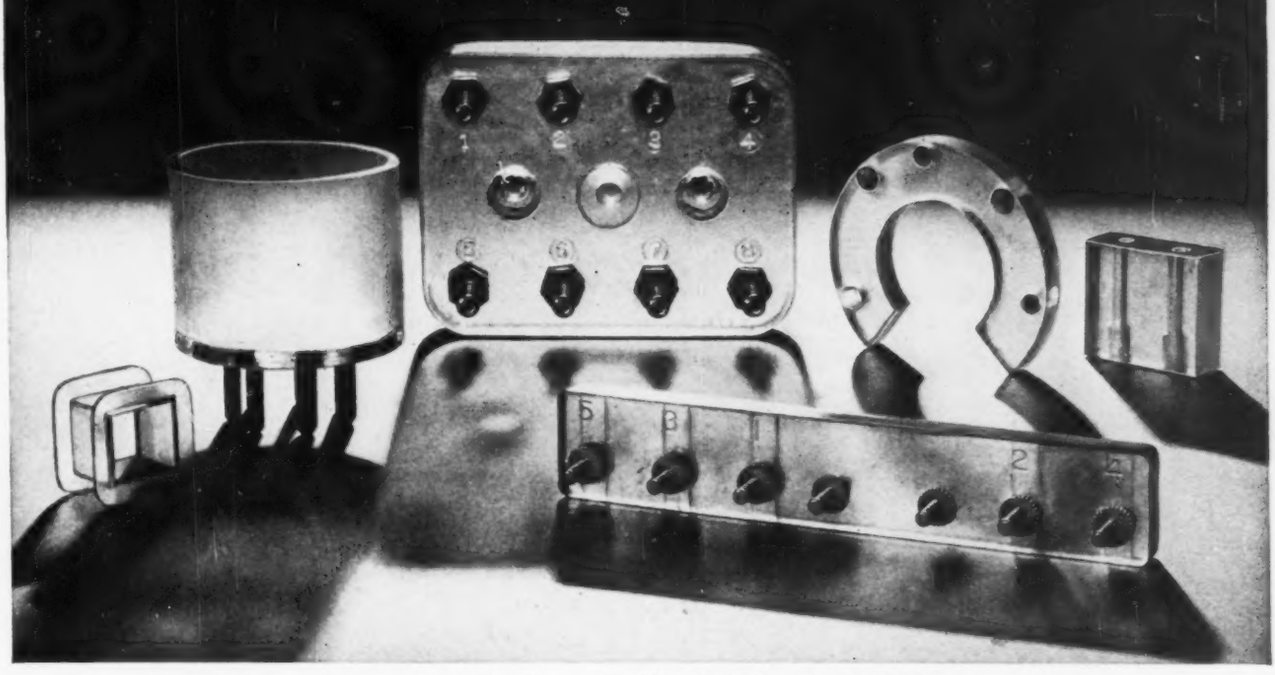

Advantageous applications of Bakelite XMS-10023 Material include: coil forms, tube bases, terminal blocks, spacing washers, connector blocks.

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From the diagram it may be seen that a potentiometer voltage from the generator terminals is bucked against a battery, the voltage difference (approximately 2 volts) being applied to the grid of a voltage amplifier tube,

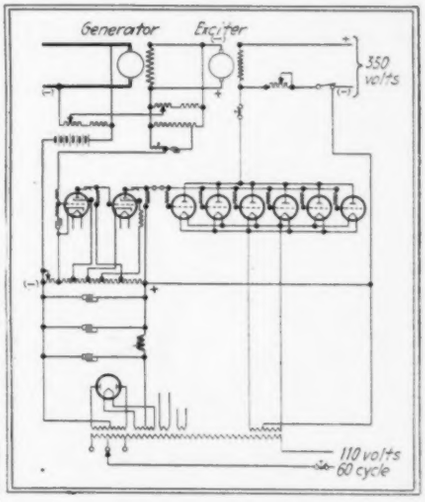


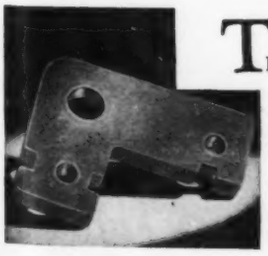
Diagram of electronic voltage regulator for d-c generators

and the plate current from this tube is applied across a resistor to the grid of a second voltage amplifier tube, the output of this second voltage amplifier tube then being of sufficient magnitude to control the grids of six current amplifier tubes connected in parallel. These current amplifier tubes supply a portion of the field current of an exciter that is energized from a separate 350 volt d-c. supply. In this manner, voltage changes at the terminals of the generator as small as 0.1 or 0.2 volts are amplified through two voltage amplifier tubes until they are of sufficient magnitude to control the grids of current amplifier tubes that apply a corrective force to the field of the exciter.

A rectifier with filter provides a source of d.c. from an a-c supply for energizing the various elements of the tubes in the regulator. The regulator can easily be adjusted to be insensitive to changes in a-c voltage of plus or minus 5 per cent.

The anti-hunting device consists of a potentiometer across the exciter armature and a capacitor in series with a resistor. When the regulated voltage is normal, the exciter armature voltage is constant and the voltage drop across the resistor is zero. If the exciter armature voltage is changing

THIS EYE NEVER SLEEPS



TRAFFIC LIGHTS must be dependable because they control the safety of wave after wave of travelers at cross purposes. That is one reason why *Synthane* Bakelite-laminated is used for insulating traffic light circuits—that plus *Synthane's* combination of mechanical strength, low moisture absorption and high dielectric strength. *Synthane's* great value lies in its unusually broad *combination* of physical, electrical, chemical and mechanical properties. *Synthane* is a uniformly dense, solid material. It is tough, strong and light in weight; one of the most effective dielectric materials—combining low power factor, low moisture absorption, high dielectric strength and low dielectric constant. It is chemically inert; corrosion resistant; easy to machine. The uses for *Synthane* are countless. Just as its combined properties are necessary for insulating traffic lights, so it may be of *material* assistance in the manufacture of your product. *Synthane* is often the most economical material to use. Write for "*Synthane* for Mechanical Applications", telling us in your request your requirements.

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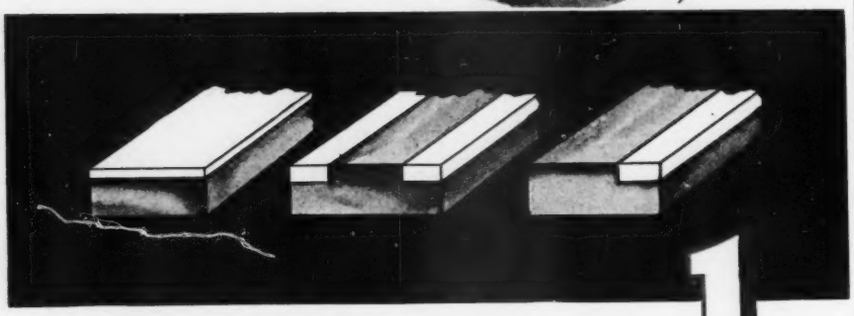

1

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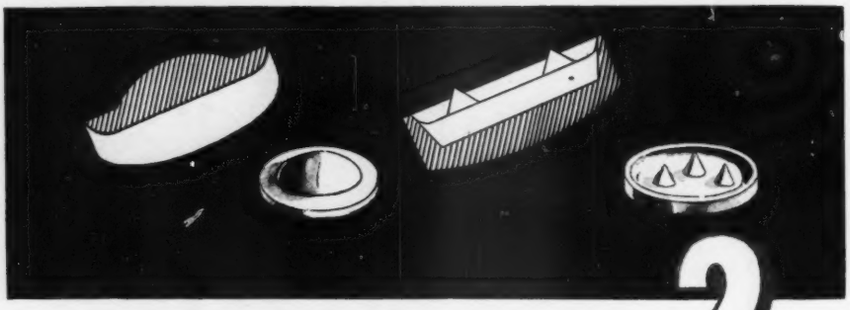

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in order to correct a variation in the regulated voltage, there will be a voltage drop across this resistor. The polarity of this voltage drop depends upon whether the exciter voltage is increasing or decreasing, and the magnitude of the voltage drop will be proportional to the rate of change of the exciter armature voltage. The anti-hunting connection is not made if an exciter is not used, and the field of the generator is supplied from a separate source of 350 volts d.c. to which the corrective action of the regulator is applied.

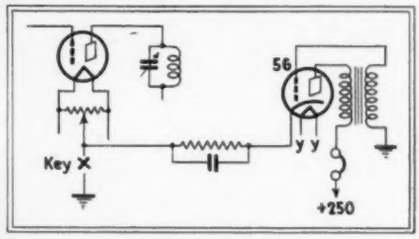
• • •

Keying Monitor for C-w Transmitters

By Henry Perozzo

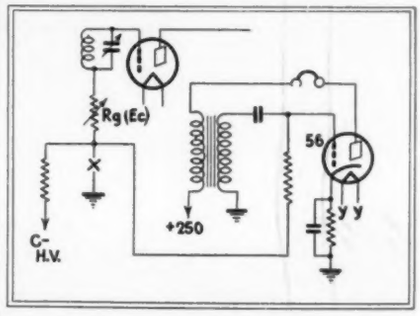
Braniff Airways, Oklahoma City

A KEYING MONITOR having clear characteristics, and which will operate automatically without switching between receiving and sending periods is a distinct aid toward good keying, particularly when traffic is heavy, and the



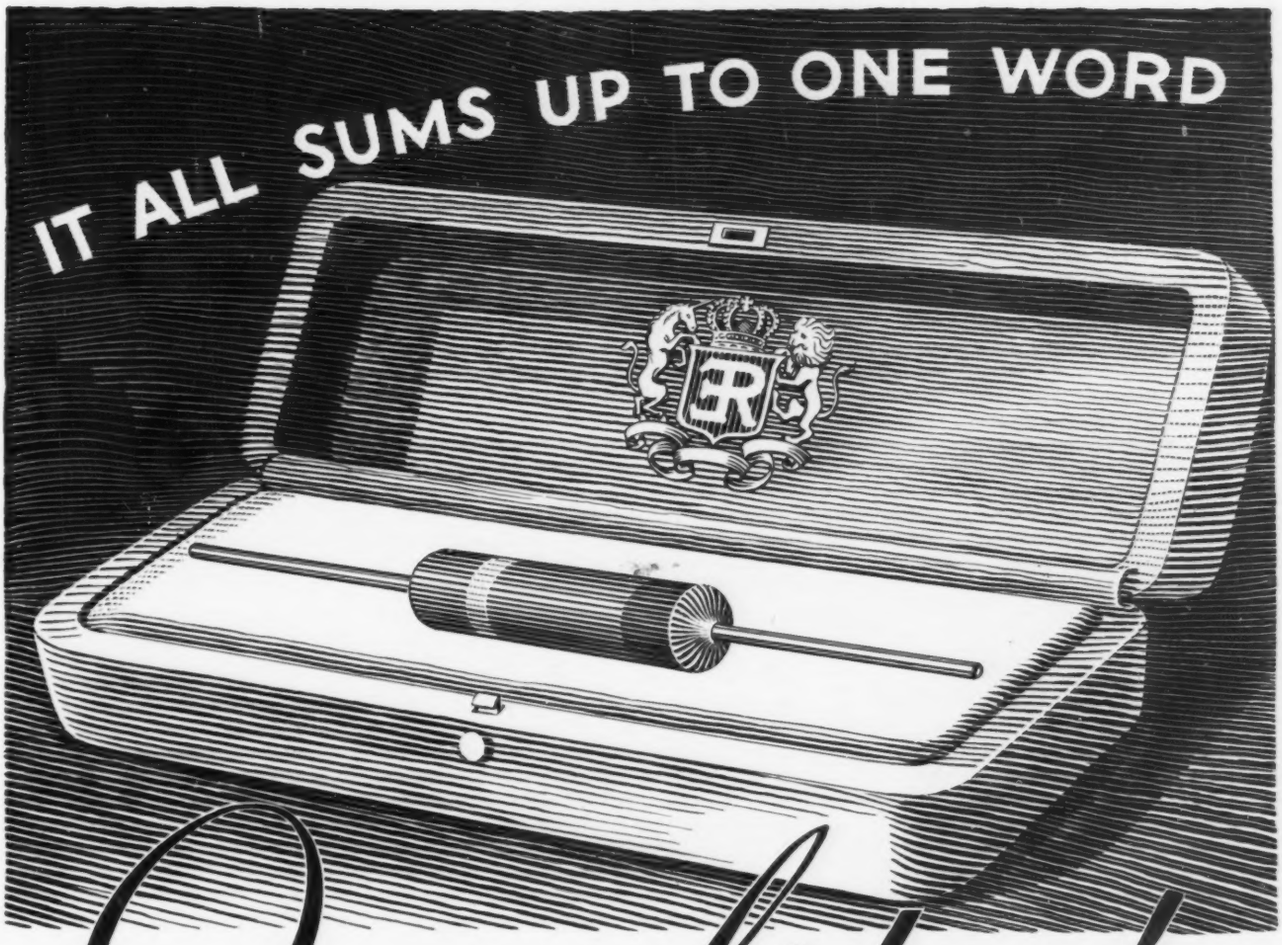
Center tap keying circuit

operator cannot bother to switch his receiver, or other monitor. Relays and an audio oscillator answer the purpose, but the modern trend is to incorporate keying systems which do not



Keying in the grid circuit of power tube

use relays. The circuit shown can be used in most cases with very little change in the equipment used. In the first circuit, because of the high voltages involved, a separate filament transformer is usually necessary for the keying tube, but when the grid circuit is keyed, a case that is rather difficult to monitor in any other simple manner, the second circuit proved out admirably.



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Audio Transformers Sealed in Aluminum Cans

By Reuben Lee
Westinghouse Elec. & Mfg. Co.
Chicopee Falls, Mass.

THE OLD DIFFICULTY of protecting small transformers against tropical humidity conditions recently has been solved by the use of the familiar aluminum condenser can. Obvious advantages of this type of can are: There is only one joint to seal, the can is very light, and it is inexpensive because of the enormous quantities used in condenser manufacture. This method is one of the unusual cases where a better product turns out to be easier to make, once the proper manufacturing facilities are set up.

The principal parts of such a transformer are displayed in the figure: the can, gasket and electrical parts unit. Some care naturally has to be given to these constituents. The gasket material is a cork and synthetic rubber compound, providing strength and sustained resilience. The terminal board is made of a non-hygroscopic ceramic, and the terminals must be very carefully soldered to avoid blow holes. All terminals are sealed by individual gaskets and special non-absorbent varnish filler. By mounting the terminal board on the core before the complete assembly is done, manufacture is much facilitated. The electrical parts unit is dropped into the can, the terminal board resting on the formed ledge. After being coated with varnish filler,

Shield can and transformer

the gasket is placed on the terminal board, and the transformer is ready for spinning.

Spinning the top of the can likewise calls for some care. It must be uniformly done, else the can or the terminal board will crack. The edge of the can must penetrate the gasket without mutilating it, and must penetrate evenly to produce a tight seal. This difficult operation is performed readily by using a drill press fixture having adjustable rollers, which rounds the edges of the can down the requisite amount with but slight pressure from the operator's hand.

After spinning, the seal is given a final coat of varnish and the transformer is baked to drive off the solvent in the seal. Samples are subjected to a severe cyclic humidity test, and no failures traceable to the seal have occurred.

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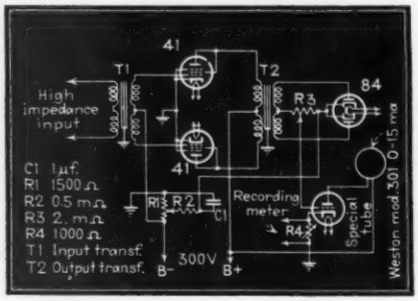
Transmission Measuring System

IN THE JULY 1937 issue of the *Journal of the Society of Motion Picture Engineers*, W. W. Lindsay, Jr., describes a "Transmission Measuring System Utilizing a Graphic Recording Meter." The equipment described may be used to make gain-frequency runs on communication equipment, as a recording microdensitometer, a recording volume indicator or for making records for various transient phenomena. The output of the pick-up is sufficient to operate a 5 milliampere Esterline Angus recording meter.

In order to obtain the logarithmic response connecting the input and output of the system, the author has developed the simple circuit shown. This circuit requires the use of a special triode in which the plate current and grid bias bear a logarithmic relation to one another. The author indicates that the usual variable μ or exponential control types of tube do not follow this characteristic accurately or over a sufficient range to be of much value. Essentially, the circuit consists of a push-pull class A amplifier which terminates in a full-wave linear rectifier. Linearity of the rectifier characteristics is assured by making the external load resistance large compared with the tube conductance. The negative bias voltage produced as a result of signal rectification is applied to the grid of the triode. With this arrangement the plate current of the special triode is a logarithmic function of the signal voltage applied to the class A push-pull amplifier.

The power range of this system is limited by the ability of the class A amplifier to supply signal voltage to the rectifier without overloading. It is also limited by the tube parameters of showing the special logarithmic triode. The author shows a curve in which a range of 40 decibels has been obtained. It should be possible to extend this range considerably through the use of several similar cascaded stages. The reader should also consult F. V. Hunt, *Rev. Sci. Instruments*, December, 1933.



Schematic wiring diagram of the recording transmission system

Compensating Circuit for Blocking-Layer Photoelectric Cells

A COMPENSATING circuit comprising two blocking-layer photoelectric cells in a parallel combination with galvanometer and voltage dividing rheostat is described by Brooks A. Brice in the August issue of the *Review of Scientific Instruments*. Analysis of the compensating circuit shows that a uniform scale attached to the rheostat may be used to indicate transmission of light by a sample if the resistance of the potentiometer and series internal resistance of the cells are small in comparison with the parallel internal resistance of the photoelectric cell. With moderate illumination on the photoelectric cells and using a 50-ohm potentiometer rheostat, carrying the scale from 50 to 100, errors in indicating transmission are believed to be not greater than $\pm$ 0.1 on this scale.

Listing of Cathode Ray Tubes

AN INTERESTING and useful listing of commercial cathode ray tubes is given by Ralph R. Batcher in the October issue of *Instruments*. This list gives characteristics on about 40 vacuum and gas type cathode ray tubes made by DuMont, General Electric, General Radio, Hygrade Sylvania, National Union, Radiotron Division of RCA, Western Electric and Westinghouse.

Recording Resistance Welder

[*Continued from page 17*]

by the application of voltage to the reactance of the secondary in advance of the power-factor angle, and the reduction of secondary current on the positive half-cycles caused by internal voltage drop due to the exciting current transient.

The pick-up coil method may be further simplified by eliminating the air-core coil and using the reactor L as both pick-up coil and reactor. Figure 6 shows an oscillogram of this method of recording, and Fig. 2 shows the diagram of connections. Vibrator V_2 on the secondary of a current transformer was added to compare the three methods of recording. The shunt across V_1 is a 25-ampere oscillograph shunt, that across V_2, a 1-ampere shunt on the secondary of a 100:1 current transformer, and the pick-up reactor L is a type 9XD-83A1 reactor manufactured by the General Electric Company. The reactor must be placed relative to the secondary circuit of the welder so that the current flowing in the vibrator shunting the reactor is just sufficient for a good deflection. Too strong a field will saturate the iron of the reactor and cause distortion in the recording. This is a disadvantage when used on a welder having a wide range of operating currents as the reactor position must be shifted to cover the range without introducing distortions from saturation. However, if the reactor is mounted so as to permit rotation through a 90 degree arc, this method of pick-up will cover a large range of currents.

Application of Pick-up Coil Method

Since the calibration of the pick-up coil method depends upon the mutual inductance between the secondary circuit and the pick-up coil, it is necessary to calibrate the equipment after it is attached to the welder. The secondary current at low heats, with the electrodes shorted, may be fairly accurately determined by multiplying the steady-state primary current by the turns ratio of the welder transformer for the corresponding heat setting. A measurement of the oscillograph deflection for a known secondary current provides a reasonably accurate over-all calibration. A tapped pick-up coil provides a convenient means for varying the calibration to suit the different operating currents of the various welder sizes. Figure 5 shows such a coil in position on 150-kva welder. The coil consists of 800 turns of No. 25 enameled wire wound on a 2-inch diameter tube 3 inches long and tapped at 200 and 400 turns. The reactor used in series with the vibrator and coil was the General Electric type 9XD-83A1. This reactor is rated one henry with 0.3 ampere d.c. through the winding and weighs about one pound. The pickup coil described above weighs about ten ounces so the entire accessory equipment for a PM12 oscillograph weighs about one-fifth that of a standard 500-ampere "clamp-on" current transformer.

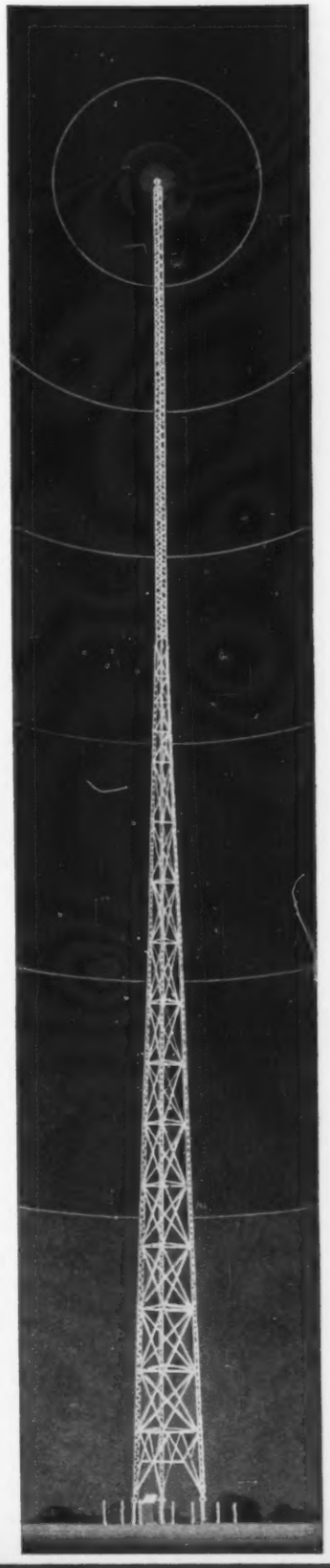
STATION	LOCATION	TOWER HEIGHT
WDOD	Chattanooga, Tenn.	320'
WADC	Akron, Ohio	350'
WLW	Cincinnati, Ohio (2 towers)	322'
WDGY	Minneapolis, Minn.	184'
KGHL	Billings, Mont.	558'
WSVA	Harrisonburg, Va.	182'
WTMV	E. St. Louis, Ill.	154'
WMFE	New Britain, Conn.	185'
KTRH	Houston, Texas	375'
WBNX	Cliffside, N. J. (2 towers)	235'
WIS	Columbia, S. C.	352'
WIS	Columbia, S. C.	260'
WOKO	Albany, N. Y.	180'
WGAR	Cleveland, Ohio	374'
WCOP	Boston, Mass.	227'
WELI	New Haven, Conn.	281'
WJAX	Jacksonville, Fla.	281'
WEMP	Milwaukee, Wisc.	173'
WJJD	Mooseheart, Wisc.	281'
WREC	Memphis, Tenn. (2 towers)	410'
KOMO	Seattle, Wash.	570'
KFBK	Sacramento, Calif.	334'
WDRC	Hartford, Conn.	308'
WFBC	Greenville, S. C.	375'
KBTM	Jonesboro, Ark.	189'
WIBA	Madison, Wisc.	430'
WIBA	Madison, Wisc. (2 towers)	195'
WTAQ-WHBY	Green Bay, Wisc. (4 towers)	196'
WDAE	Tampa, Florida	238'
WFMD	Frederick, Md.	257'
WSAI	Cincinnati, Ohio	225'
WHBL	Sheboygan, Wisc.	285'
	Canton, China	622'
WSPR	Springfield, Mass.	222'
KFEL	Denver, Colo.	285'
WROK	Rockford, Ill.	238'
WAAF	Chicago, Ill.	231'
WCLO	Janesville, Wisc.	259'
WSIX	Nashville, Tenn.	195'
KFPY	Spokane, Wash.	466'
WSBC	Chicago, Ill.	195'
WTRC	Elkhart, Ind.	174'
	Tallin, Esthonia	645'
WKY	Oklahoma City, Okla.	285'
KMA	Shenandoah, Iowa	488'
KWYO	Sheridan, Wyo.	187'
KRSC	Seattle, Wash.	218'
WNBF	Binghamton, N. Y.	227'
WORL	Boston, Mass.	308'
WCBM	Baltimore, Md.	231'
KLRA	Little Rock, Ark.	300'
KVI	Tacoma, Wash.	444'
KID	Idaho Falls, Idaho	330'
WGRC	New Albany, Ind.	231'
WIRE	Indianapolis, Ind. (2 towers)	330'
WTAD	Quincy, Ill.	280'
WDWS	Champaign, Ill.	152'
KOBH	Rapid City, S. D.	174'
WILL	Urbana, Ill. (2 towers)	333'
WEEI	Boston, Mass. (2 towers)	364'

POLICE TOWERS

WMP	Framingham, Mass. State Police	220'
WQPS	Springfield, Ill. State Police	338'
WQPC	Chicago, Ill. State Police	338'
WQPP	Pontiac, Ill. State Police	338'
WQPG	Sterling, Ill. State Police	338'
WQPM	Macomb, Ill. State Police	338'
WQPD	Duquoin, Ill. State Police	338'
WQPF	Effingham, Ill. State Police	338'
KACD	Atlantic, Iowa State Police	227'
KACC	Fairfield, Iowa State Police	227'
W9xHG	Terre Haute, Ind. City P. D.	154'
	Boston, Mass. City P. (3 towers)	132'
	Oregon State P. D. (8 towers)	120'
	Dept. of Commerce Lighthouse Service, New York	125'
	Montgomery, Ala. Police Dept.	95'

ERECTED IN 1937

WHDL	Olean, N. Y.	308'
KDKA	Pittsburgh, Pa.	710'
KFEQ	St. Joseph, Mo.	330'
WFOY	St. Augustine, Fla.	200'
WSMB	Algiers, La.	375'
KGLO	Mason City, Iowa	290'
WRBL	Columbus, Ga.	210'
KRNT	Des Moines, Iowa (2 towers)	194'
WGR-WKBW	Buffalo, N. Y.	400'
WCAX	Burlington, Vt.	250'
WXYZ	Detroit, Mich.	277'
WATL	Atlanta, Ga.	154'
KGW	Portland, Ore.	625'
KOIL	Council Bluffs, Iowa	308'
KSFO	San Francisco, Cal.	350'
KSRO	Santa Rosa, Cal.	190'
WKBN	Youngstown, Ohio	344'
WEDC	Chicago, Ill.	210'
KPQ	Wenatchee, Wash.	174'
WIND	Gary, Ind.	359'
WAGA	Atlanta, Ga.	375'



STATION	LOCATION	TOWER HEIGHT
WCBD	Elmhurst, Ill.	410'
KPFA	Helena, Mont.	160'
WICA	Ashtabula, Ohio	217'
WJDX	Jackson, Miss.	340'
KICA	Clovis, New Mexico	179'
WCOC	Meridian, Miss.	273'
WOAI	San Antonio, Texas	425'
WRC	Washington, D. C.	400'
KGVO	Missouli, Mont.	220'
WOMI	Owensboro, Ky.	185'
KOTN	Pine Bluff, Ark.	154'
KFYR	Bismarck, N. Dakota	700'

POLICE TOWERS

WPEW	Northampton, Mass. State Pol.	218'
KGHO	Des Moines, Iowa Bur. of Invest.	227'
KNFN	Cedar Falls, Iowa Bur. of Invest.	135'
	Niagara Falls, N. Y.	110'
	Tampa, Fla. Police Dept.	94'
WMDZ	Indianapolis Police Dept.	215'
WPDK	Milwaukee Police Dept.	225'
WPEC	Memphis Police Dept.	218'

AND THE LIST GROWS LONGER

Which indicates that Truscon Vertical Radiators are gaining rapid acceptance through their proved ability to increase a station's primary and secondary service areas with no increase of power input; to increase signal strength; to increase fading free area; to maintain consistently the efficiency of directional systems; to maintain highest effective radiation; to reduce the interruption hazard because of maximum structural stability; and to accomplish various additional commercial and engineering advantages.

Truscon Vertical Radiators are economically designed and structurally sound . . . capable of resisting terrific wind pressures of hurricane intensity. They are available up to five eighths wave lengths, either uniform cross section guyed or of narrow base self-supporting type, throughout the complete range of broadcasting frequencies.

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YOUNGSTOWN, OHIO

TRUSCON VERTICAL RADIATORS

THE ELECTRON ART

EACH month the world's technical literature is scanned to see what physicists and engineers are doing with tubes, for presentation in tabloid form to Electronics' readers.

French Push Button Radio Receiver

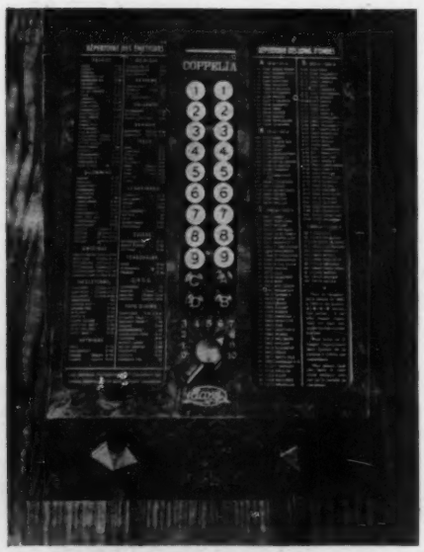
ALTHOUGH PUSH BUTTON TUNING is one of the features brought out this year by American radio manufacturers, push button tuning has also received considerable attention in Europe.

Shown in the accompanying photographs are views of the Coppelia automatic receiver of Electro-Construction S.A., at Strasbourg. Introduced in 1936, this receiver makes provision for automatic tuning of up to 150 stations by pressing down not more than two keys, one in each column. Selection of the correct wave band is attained by pressing down the keys A, B, C, or D, these four keys permitting the user to select five wave bands.

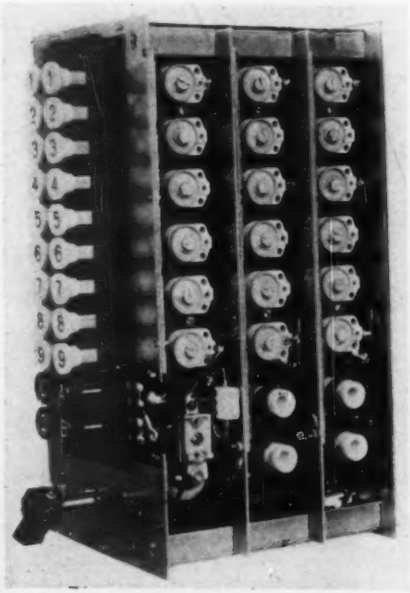
Advantages claimed for this French receiver are that selection is noiseless, stations can be identified easily at all times, the selector scheme used is stable and will withstand shipment, and finally no relays or motors are employed.

The construction of the automatic selector is relatively simple. Only eight fixed capacitors are necessary for each variable tuned circuit for station selection. In one of the photos showing the interior construction of the coil of the station selector unit, the first column of units nearest the push button are the oscillator coils and condensers. The corresponding elements for the high frequency amplifier are in the middle column, whereas those for the antenna circuit are at the column at the right. The coils are shown at the bottom of the illustration whereas the adjustable condensers are shown as the upper six adjustments in each column.

In operation, the time required to select a station is less than one second and as soon as the station has been selected, broadcast reception is instantaneous. The station selected can be identified at all times, the system can be used for remote control, and a change of the station wave length necessitates only an exchange of the scale without any technical manipulation. A supplementary code will serve to find broadcasting stations which are not indicated on the main scale as well as newly constructed stations.



Panel of French push button tuned radio receiver showing the two rows of buttons by which stations may be selected. The four keys at the bottom, select the wave band



Interior of the push button tuning assemble showing the coils, condensers, and trimmers

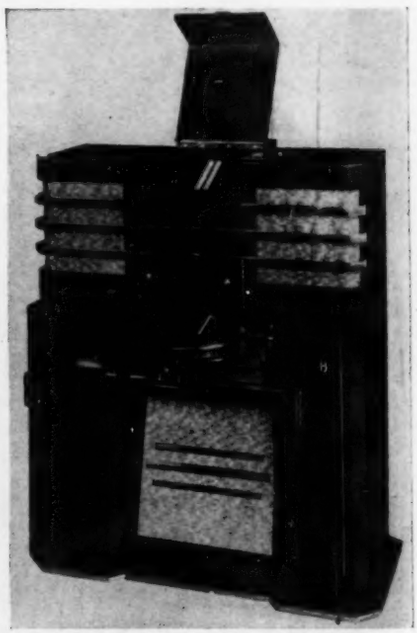
Production of Millimeter Waves

EXPERIMENTAL METHODS of production and applications of electromagnetic waves in the millimeter region are described by Neil H. Williams in the October issue of the *Journal of Applied Physics*.

One of the significant features of the work on short electromagnetic waves and described by Williams in his article "Production and Absorption of Electromagnetic Waves from 3 cm. to 6 mm. in Length" is that it opens a new region of the spectrum for quantitative study. It is pointed out that this region is not likely to be a very exciting one since, because it falls between that of the shorter electric wave and the longer heat wave, its properties may be estimated by interpolation.

For the production of these millimeter waves, magnetrons are used. Depending upon the wave length to be produced, the anode voltage varies from 800 to 1,400 volts. The magnetic field surrounding the tubes is adjusted almost to cut-off so that an increase of the potential of one-half of the anode will cause the electron stream to be deflected to that half. The potential of the other half of the anode is thereby reduced and the electrons are sent to the other half. Oscillations may thereby be set up whose frequency is dependent upon the time of flight of electrons between the two halves of the anode and the LC constants of the tuned circuit attached to the tube.

In the magnetron used for production of the shortest waves, the radius of the anode is only two-tenths of a millimeter and the Lecher system attached to it is less than 4 mm. in length.



Phonograph-radio combination with "cash register" push button tuning

Size is an indication of something important to you as a buyer of radio components. However, we take far more pride in Sprague's consistent record of **engineering supremacy** than in the world's largest condenser factory which came as its natural result.

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GOOD CONDENSERS—EXPERTLY ENGINEERED—COMPETENTLY PRODUCED

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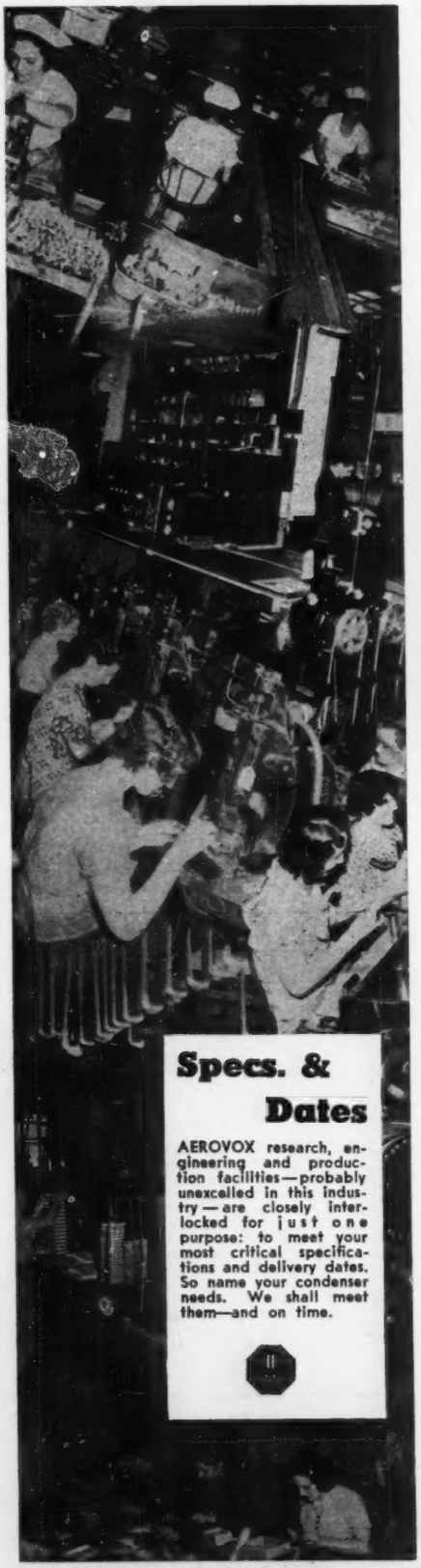
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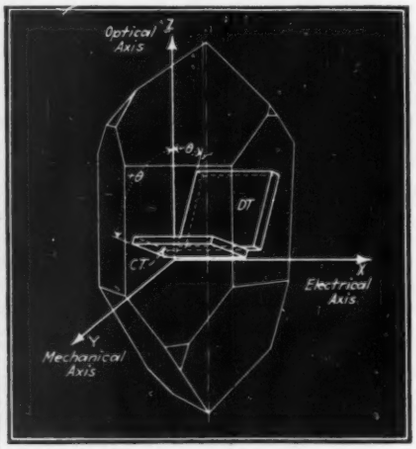
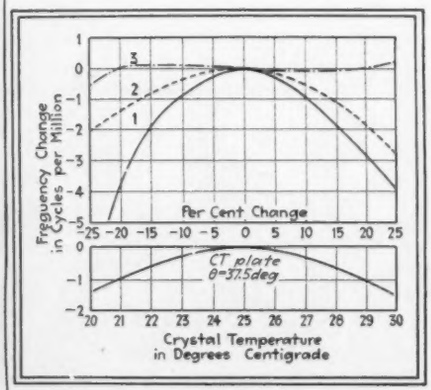
Standard Frequency Quartz Plates

EVER SINCE the fundamental work of Cady, Pierce and Miller in applying quartz crystals to stabilize the frequency of vacuum tube oscillator, the search for improved frequency stability has continued. In an article "Quartz Plate for Frequency Sub-Standards," F. C. Hight describes some new experiment in the September issue of the *Bell Laboratories Record.*



Orientation of zero temperature-coefficient quartz plates

Developed for use at frequencies lower than the common broadcast spectrum, the new CF and DF cut crystals developed by the Bell Laboratories have several advantages over former cuts. The frequency of these new quartz plates may be either raised or lowered by simple abrasion and the temperature coefficient may be changed either positive or negative by abrading the faces so as to alter effectively the orientation of the cut a slight amount with regard to the crystal axis. These two adjustments enable a plate to be precisely adjusted to frequency, so that slight errors in large scale production methods may be counteracted if necessary.



Stability with variations in (1) feedback, (2) plate reactance or (3) applied voltage

For operation at room temperature, the angle of cutting for the CT plate should be +37°30′ with respect to the Z axis. With this type of cut the frequency will be maintained to within one part in a million of the desired value for a variation in temperature of from 20° C. to 30° C. Even less frequency variation occurs for the type DT cut.

The article concludes with a graph which shows that the temperature is maintained to within one part in a million for the CT cut plate with an operating temperature of 25° ± 5° C. For the CT cut plate, the frequency change is considerably less than one part in a million for any normal voltage variations which are likely to be encountered. A change of frequency of one part in a million may result from a 15 per cent change in the feedback capacity, or by a 17 per cent change in the reaction of the plate circuit.

The net result is that the new type of plate can be used as a sub-standard without requiring the elaborate voltage compensating and temperature regulating devices which have been standard equipment on most of the better crystal control frequency standard installations.

• • •

Nine Audio Channels on Single Carrier in Scotch-Irish Telephone Circuit

MAKING USE of the ability of ultra high frequency transmitters to modulate over a wide band of frequencies, engineers of the British Post Office have recently put in service an ultra high frequency radio link between Belfast, Ireland and Stranraer, Scotland which transmits nine telephone conversations simultaneously over a single carrier. The main carrier operates on a frequency of 76 megacycles. This carrier is modulated over a side band 150 kc. wide. Each side band is divided into nine channel frequencies separated by 15 kc. Each of these channel frequencies is in turn modulated at audio frequency (maximum frequency about 3,000 cycles). The system in effect employs double modulation, the main carrier being modulated by a system of "channel frequencies" which in turn are modulated at audio frequencies.

The receiver, of the superheterodyne type, employs a bank of nine selecting circuits operating as band-pass filters to separate the individual channel frequencies, which are then detected and delivered to the nine audio channels. Both the transmitter and the receiver are crystal controlled to maintain the necessary constancy of frequency. For the reverse-direction circuit the nine channels are transmitted on a carrier frequency of approximately 83 megacycles. The transmitted and received waves are polarized at right angles to each other, to minimize mutual inter-

YOUR FINAL CHANCE

Because orders for the 1937 set of electronic charts were continually arriving in large numbers we have postponed the publication date to December 20th.

If YOU have not already placed your order, do so NOW because sets will be printed for only the number of orders on hand.

Electronics Yearly Service was inaugurated at the request of subscribers for an opportunity to secure an extra set of the Reference Sheets that had appeared in all the issues during the current year. These will be printed on heavy stock, punched and ready for insertion in the notebook. Only bona fide subscribers as of publication date are entitled to secure this extra service.

The 1937 set will consist of 21 pages with the following Reference Sheets: Solenoid Inductance Chart — Resistance-Amplifier Data — Resistance Values for Multiple-Circuit Pads—Electronic Engineers' Library — Slide-rule Impedance Calculations — Universal Amplification Charts — Mutual Inductance Chart — Nuclear Physics Chart — Television Terms — Condenser Discharge Chart — Bars Compensation Design Chart — Class B R-F Amplifier Chart — Allocation in the Ultra-high Spectrum.

The cost is only $1.00 plus a small delivery charge — If you send payment with your order — eliminating bookkeeping and collection expense — we will pay delivery charge.

This is the ONLY opportunity you will have to obtain a complete set of 1937 charts. We will not be able to fill orders after publication date.

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This coupon is for your convenience. Use it—or a postcard mailed NOW will insure you of a complete 1937 set of charts. You can't afford to delay.

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trying to build a piano?

A piano has 18,000 parts — more than three times as many as are incorporated in an automobile. It contains 9,000 pieces of wood. The *action* requires 5,648 separate pieces.

That is a Complicated Job!

Here is a simple one!

The electronics field has six major divisions, namely: 1. The Radio Industry — 2. Broadcasting and Communication — 3. The Sound Industry — 4. Industrial Manufacturers — 5. Electrical Manufacturers — 6. Electrical and Testing Laboratories.

These six major divisions are divided into 16 important groups, namely: *Manufacture* (1) of home and auto radio, facsimile, television, phonograph — (2) of commercial communication equipment, broadcast, etc. — (3) Of non-communicating tube equipment including therapy — (4) of measuring equipment — (5) of components. *Operating companies* (6) in sound, records, pictures, public address — (7) in broadcasting — (8) in radio communication including amateurs — (9) in wire and cable communication. *Industrial companies,* such as (10) utilities—(11)metal mining and fabricating—(12) process industries — (13) transportation. (14) Universities and their laboratories. (15) Independent laboratories and consultants. (16) Government, State and Municipal executives and engineers.

Every important man and company in these groups — 12,000 of them, with 30,000 pass-on readers — study ELECTRONICS sales messages every month. There is no (dead) wood in this circulation, because they pay $5.00 a year for a publication they need in their $2,000,000,000 business.

Action in this field requires ELECTRONICS alone. No other single publication — NO GROUP OF PUBLICATIONS — can reach the buyers and influencers of purchase of products in fields allied to electronics with the depth of penetration, height of reader interest — and *economy*. We can prove it statistically — our advertisers prove it by *results*. It's easy to build business on the simple ELECTRONICS pattern.

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Greetings
We attempt to demonstrate that, no matter how you twist, bend, snarl or crush TURBO Oil Tubing, it will always resume its true tubular shape.

WILLIAM Brand and Company extend to the Radio and Electrical Industries greetings and sincere wishes for a happy holiday time.

May 1938 open new vistas of bounteous prosperity and happiness for you, and all who are associated with you. This coming year holds a promise of the greatest progress in industry's history.

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Model 99B. List Price..... $12

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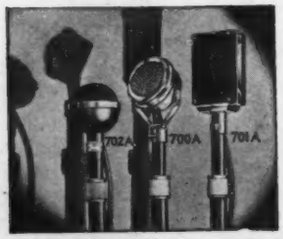

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You're sure of better, truer, more accurate reproduction than ever before available even at higher cost! And you get exclusive dependability-features that give extra-protection against the most rigorous service conditions. Thousands of Shure "ULTRA" Microphones are in use in more than 36 countries throughout the world.

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Shure patents pending. Licensed under patents of the Brush Development Company

ference between them. One of the features of the receiver are the special channel selecting circuits which must have extremely sharp characteristics to avoid crosstalk between the separate channels.

The equipment is designed for remote operation in unattended stations, controlled from the nearest telephone exchange. Complete duplicate equipment is provided in case of failure; this spare equipment is switched automatically into the circuit in the event of failure of the normal circuit. Extensive protective measures of this sort are necessary since all nine channels are lost if the equipment fails. For the same reason power supply is duplicated, an emergency Diesel-operated generator being switched in the event of failure of the public supply, within one minute of the failure. The equipment was installed and designed by engineers of Standard Telephones & Cables Limited, of London.

• • •

Re "Screens for Television Tubes"

MR. I. G. MALOFF, one of the co-authors of "Screens for Television Tubes" which appeared in the November issue calls attention to errors in the integration limits of Eq. (2) and Eq. (3) on page 34. Equation (2) should read

$$I_1 = N \int_{\theta=0}^{\theta=2\pi} d\theta \int_{\phi=48°}^{\phi=90°} \cos\phi \sin\phi \, d\phi$$

$$= 0.448\,\pi N \text{ lumens} \quad \ldots\ldots\ldots\ldots (2)$$

and Eq. (3) should read

$$I_2 = N \int_{\theta=0}^{\theta=2\pi} d\theta \int_{\phi=0}^{\phi=48°} \cos\phi \sin\phi \, d\phi$$

$$= 0.552\,\pi N \text{ lumens} \quad \ldots\ldots\ldots\ldots (3)$$

• • •

Magnetic Recording

IN AN ARTICLE entitled "Magnetic Recording and Reproducing," by C. N. Hickman in the September issue of the *Bell Laboratories Record*, it is pointed out that during the past quarter of a century the failure of utilizing Poulsen's system of magnetic recording on a steel wire was due to a number of causes. In the first place the original experiment used round wire whose magnetic properties were not ideally suited to the intended purpose. Furthermore, suitable amplifiers were not available at the time the Poulsen system was invented.

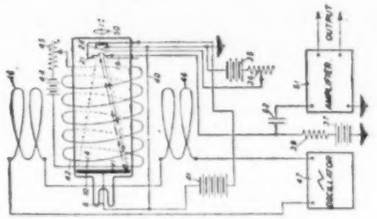
Through the use of a very thin and narrow tape instead of a round wire, and the use of perpendicular magnetization (i.e. the magnet element in the tape had no appreciable component along the length of the tape) the Bell

U. S. Patents

Television

Interference Prevention. Circuits for generating interfering signals along with picture signals and then getting rid of interfering signals. R. L. Campbell, RCA. No. 2,092,875.

Image Dissector. P. T. Farnsworth, No. 2,087,683. Image amplifier, No.



2,085,742; Multipactor, 2,091,439; Projection system, No. 2,091,705.

Generator. Saw-tooth wave producer. M. Bowman—Manifold, EMI. No. 2,097,334.

Braun Tube. Use of material having greater fluorescence than phosphorescence. M. Von Ardenne, D. C. Loewe, No. 2,096,986. See also No. 2,096,895 von Ardenne on a deflection system. Also 2,096,987, 2,096,988.

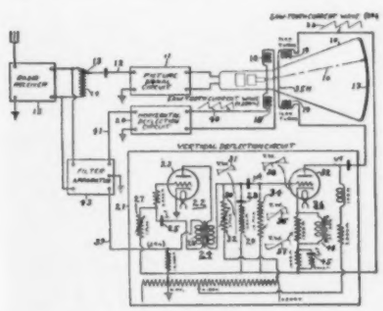
Saw-tooth Generator. Kurt Schlesinger, Berlin. No. 2,096,982.

Deflecting System. Electromagnetic system. T. Nakashima and K. Takayanagi, Japan, No. 2,093,157.

Synchronizing Impulses. R. C. Ballard. RCA. No. 2,093,395.

Deflection Circuit. A. W. Vance, RCA Nos. 2,085,402 and 2,093,177.

Reshaping Circuit. Method of reshaping saw-tooth waves so they will



pass through an inductive circuit without loss of shape. A. V. Bedford, RCA. No. 2,085,409. Also No. 2,092,871.

Amplitude Filter. Kurt Schlesinger, No. 2,097,804. Also No. 2,083,202 to Schlesinger on an arrangement for tilting oscillations. Also 2,083,205 on a safety means for television tubes.

Photoelectric System. Impressing an image on a photo sensitive surface, collecting the electronic emission to form an electrostatic reproduction of the image, causing an electron stream to be emitted from each point of the surface and causing the stream to be modulated by the electrostatic image. F. C. P. Henroteau, Ottawa. 1931, No. 2,083,995.

Scanning System. Cathode ray scanning. V. K. Zworykin. No. 2,084,-364. RCA.

Level Control. Cathode Ray pick-up system. G. N. Ogloblinsky, RCA. No. 2,084,700.

Radio Receiver Circuits

Automatic volume control. No. 2,083,-026, W. R. Koch; No. 2,083,025, W. R. Koch; No. 2,083,243, O. H. Schade and F. H. Shepard; No. 2,082,961, W. R. Koch; No. 2,094,902, G. L. Beers; No. 2,093,094 and 2,093,095, H. O. Peterson; No. 2,093,548, K. A. Chittick and W. L. Carlson; No. 2,097,281, K. W. Jarvis; No. 2,076,814 and 2,078,072, C. J. Franks, all to RCA. No. 2,077,045, C. K. Huxtable, Hazeltine Corp; No. 2,083,-501, W. C. Lane, Hygrade Sylvania Corp.; No. 2,093,560 and 2,093,561 to H. E. Hollman, Telefunken.

No. 2,077,126, W. J. O'Brien; No. 2,048,738, P. O. Farnham; No. 2,055,891, E. T. Dickey; No. 2,072,283, H. A. Snow; No. 2,065,910, H. A. Snow; No. 2,085,068, G. L. Beers; No. 2,088,179, W. B. Roberts; No. 2,093,565, W. R. Koch; re-issue No. 20,442, Stuart Ballantine; No. 2,088,230, D. G. Burnside; No. 2,092,885, L. R. Kirkwood; No. 2,092,500, K. A. Chittick and No. 2,092,-503, L. T. Fowler; No. 2,088,178, B. D. H. Tellegen, all to RCA.

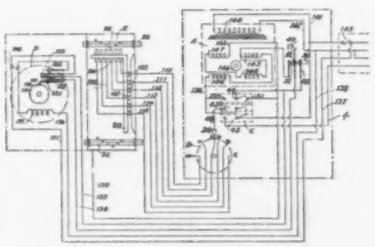
No. 2,088,206, Gunther Jobst, Telefunken; No. 2,085,928, S. A. Stevens and L. E. Thompson, Union Switch & Signal Co.; No. 2,093,564, Ernst Klotz and R. Rechnitzer, Telefunken; No. 2,072,740, D. P. Earnshaw, Philco.

Automatic tone or selectivity circuits. No. 2,076,812, P. O. Farnham, tuning selectivity control; No. 2,054,839, J. S. Starrett, automatic fidelity control; No. 2,073,504, Charles Travis, automatic tone control circuit to RCA. No. 2,074,-852, combined volume and bass tone compensation control circuit, W. H. Nelson, G.E. Co.; No. 2,092,070, tone control, P. F. G. Holst; No. 2,069,869, automatic tone control, Jacob Yolles; No. 2,085,196, selectivity control system, W. R. Koch; No. 2,088,229, automatic fidelity control, R. A. Braden to RCA; No. 2,090,538, variable band coupling device for superheterodyne, H. J. Lyman, Philco; No. 2,091,134, G. L. Beers, Westinghouse, automatic fidelity control, filed 1929, 30 claims; No. 2,078,077, L. C. Hollands, RCA, automatic fidelity control. This circuit involves an i-f amplifier having a band pass characteristic designed to pass a maximum band of 12 kc. at 90 per cent of the resonance value, a second detector and a following second i-f amplifier tuned to a frequency substantially less than the frequency of the first and passing a band width of 4 kc. at 90 per cent of resonance. No. 2,077,466, automatic volume expander, John F. Dreyer; No. 2,078,762, automatic tone control, P. F. G. Holst; No. 2,094,073, tone control system, V. D. Landon; No. 2,083,232, automatic selectivity control, W. R. Koch; No. 2,054,892, automatic fidelity control, R. A. Braden, all to RCA.

Tuning Systems

Remote control. No. 2,091,681, E. B. Hansell, New York, N. Y.

Tuning apparatus. Clock-controlled mechanism. A. A. Thomas, RCA. No. 2,097,901.



Motor tuning. J. McWilliam Stone, Operadio Mfg. Co. No. 2,093,494.

Automatic frequency control. N. M. Rust, RCA. No. 2,097,937.

Automatic station selector. Frederick W. Kiena, West Brighton, N. Y. No. 2,097,330.

Automatic frequency control. M. G. Crosby, RCA. No. 2,065,565.

Resonance indicator. The following patents are on various means of indicating resonance: No. 2,080,646, H. A. Wheeler, Hazeltine Corp.; No. 2,087,-652, H. D. Oakley, RCA; and No. 2,094,684, F. H. Shepard, Jr., RCA.

Noise Suppression Circuits. No. 2,-078,055 to W. L. Carlson, RCA, on a.v.c. with noise suppression. No. 2,076,803, J. van Slooten, RCA, No. 2,088,210 W. R. Koch, RCA interstation noise suppressor. No. 2,096,625 Geo. M. Brown, G.E. Co.

NOW—A NEW FOOL-PROOF MOTOR *for "Push-Button" Tuning*

Here is a new motor, fresh from the Alliance engineering department, specifically designed for use in radio tuning by "push-button" control.

Exclusive safety and dependability features make the Model "R" motor the most rugged and efficient of its kind. Securely mounted, self-aligning, oilless bearings guarantee permanent shaft alignment and noiseless operation. Thermostatic protection against accidental burning out, plus ample heat radiating area provided by the housing, make the model "R" ideal for concealed positions. Yet the overall dimensions are only 2⅛"x2⅛"x1½". The Alliance Model "R" motor can be had now in large quantities at low cost. Mounting and gear assemblies will be supplied to meet your particular demands and specifications.

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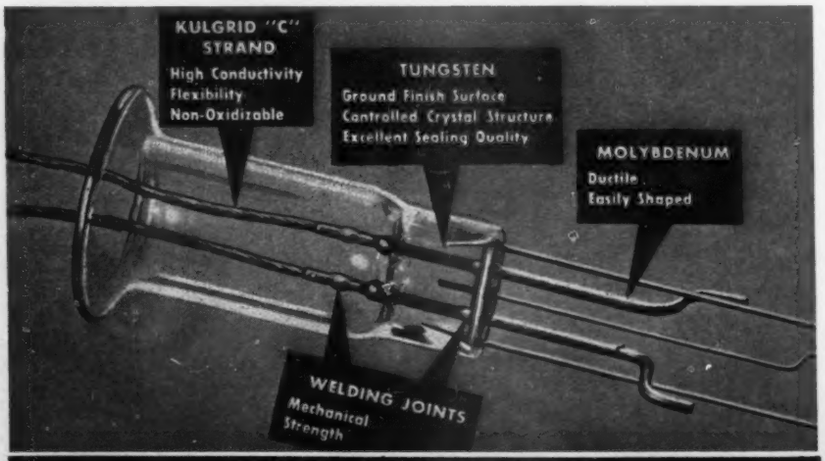

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MADE WITH
CALLITE LEAD-IN WIRES
of Tungsten • Molybdenum • Kulgrid

The TUNGSTEN in Callite Hard Glass Welds is specially processed to give a compact fibrous structure, free from longitudinal cracks and is centerless ground to eliminate surface imperfections. The KULGRID "C" STRAND has none of the objectionable features of regular copper strand. Kulgrid "C" does not oxidize. Therefore, no oxide flakes off to deposit in the tube press as is the case with copper strand. Kulgrid "C" is flexible and does not become brittle. It welds more readily to tungsten than ordinary copper strand and forms a strong joint.

Pure metals of best quality are used for any third component part.

CALLITE PRODUCTS DIVISION
EISLER ELECTRIC CORPORATION
544-39th STREET UNION CITY, N. J.

Laboratories have developed a system in which magnetic recording and reproducing can be satisfactorily carried out. In this system, the wire or flat tape which is used is strongly magnetized before reaching the recording magnet, in a direction opposite to the magnetization to be given by the recording magnet. Because the two poles of the recording magnet on opposite sides of the wire are offset with respect to each other, the flux from each pole does not follow a straight line from pole to pole. Rather, it is distributed as indicated in Fig. 1. The flux line number 1 produces little or no effect

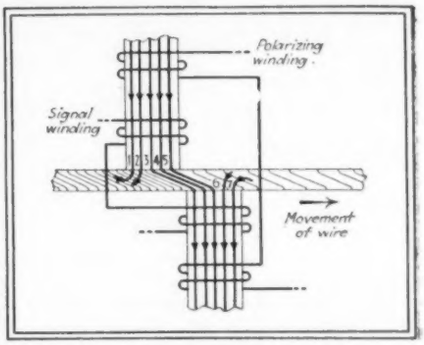

Fig. 1—Cross section of iron wire recording system

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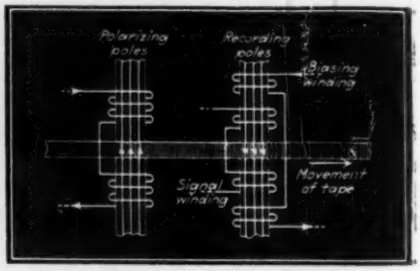


Fig. 2—Cross section of perpendicular magnitization method developed by Bell Laboratories

great enough to produce magnetic saturation of the tape as it passes between these two poles. As the tape moves from the polarizing pole the

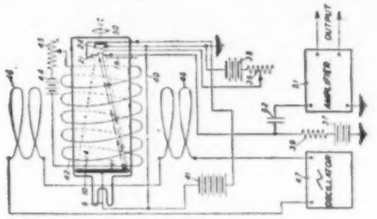
(*Continued on page* 58)

U. S. Patents

Television

Interference Prevention. Circuits for generating interfering signals along with picture signals and then getting rid of interfering signals. R. L. Campbell, RCA. No. 2,092,875.

Image Dissector. P. T. Farnsworth, No. 2,087,683. Image amplifier, No.



2,085,742; Multipactor, 2,091,439; Projection system, No. 2,091,705.

Generator. Saw-tooth wave producer. M. Bowman—Manifold, EMI. No. 2,097,334.

Braun Tube. Use of material having greater fluorescence than phosphorescence. M. Von Ardenne, D. C. Loewe, No. 2,096,986. See also No. 2,096,895 von Ardenne on a deflection system. Also 2,096,987, 2,096,988.

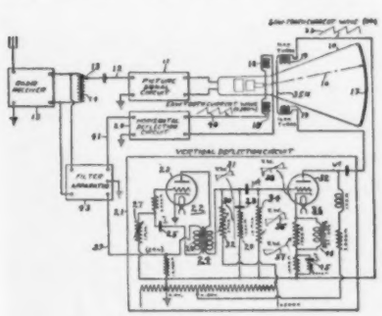
Saw-tooth Generator. Kurt Schlesinger, Berlin. No. 2,096,982.

Deflecting System. Electromagnetic system. T. Nakashima and K. Takayanagi, Japan, No. 2,093,157.

Synchronizing Impulses. R. C. Ballard. RCA. No. 2,093,395.

Deflection Circuit. A. W. Vance, RCA Nos. 2,085,402 and 2,093,177.

Reshaping Circuit. Method of reshaping saw-tooth waves so they will



pass through an inductive circuit without loss of shape. A. V. Bedford, RCA. No. 2,085,409. Also No. 2,092,871.

Amplitude Filter. Kurt Schlesinger, No. 2,097,804. Also No. 2,083,202 to Schlesinger on an arrangement for tilting oscillations. Also 2,083,205 on a safety means for television tubes.

Photoelectric System. Impressing an image on a photo sensitive surface, collecting the electronic emission to form an electrostatic reproduction of the image, causing an electron stream to be emitted from each point of the surface and causing the stream to be modulated by the electrostatic image. F. C. P. Henroteau, Ottawa. 1931, No. 2,083,995.

Scanning System. Cathode ray scanning. V. K. Zworykin. No. 2,084,364. RCA.

Level Control. Cathode Ray pick-up system. G. N. Ogloblinsky, RCA. No. 2,084,700.

Radio Receiver Circuits

Automatic volume control. No. 2,083,026, W. R. Koch; No. 2,083,025, W. R. Koch; No. 2,083,243, O. H. Schade and F. H. Shepard; No. 2,082,961, W. R. Koch; No. 2,094,902, G. L. Beers; No. 2,093,094 and 2,093,095, H. O. Peterson; No. 2,093,548, K. A. Chittick and W. L. Carlson; No. 2,097,281, K. W. Jarvis; No. 2,076,814 and 2,078,072, C. J. Franks, all to RCA. No. 2,077,045, C. K. Huxtable, Hazeltine Corp; No. 2,083,501, W. C. Lane, Hygrade Sylvania Corp.; No. 2,093,560 and 2,093,561 to H. E. Hollman, Telefunken.

No. 2,077,126, W. J. O'Brien; No. 2,048,738, P. O. Farnham; No. 2,055,891, E. T. Dickey; No. 2,072,283, H. A. Snow; No. 2,065,910, H. A. Snow; No. 2,085,068, G. L. Beers; No. 2,088,179, W. B. Roberts; No. 2,093,565, W. R. Koch; re-issue No. 20,442, Stuart Ballantine; No. 2,088,230, D. G. Burnside; No. 2,092,885, L. R. Kirkwood; No. 2,092,500, K. A. Chittick and No. 2,092,503, L. T. Fowler; No. 2,088,178, B. D. H. Tellegen, all to RCA.

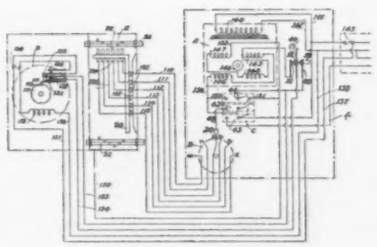
No. 2,088,206, Gunther Jobst, Telefunken; No. 2,085,928, S. A. Stevens and L. E. Thompson, Union Switch & Signal Co.; No. 2,093,564, Ernst Klotz and R. Rechnitzer, Telefunken; No. 2,072,740, D. P. Earnshaw, Philco.

Automatic tone or selectivity circuits. No. 2,076,812, P. O. Farnham, tuning selectivity control; No. 2,054,839, J. S. Starrett, automatic fidelity control; No. 2,073,504, Charles Travis, automatic tone control circuit to RCA. No. 2,074,852, combined volume and bass tone compensation control circuit, W. H. Nelson, G.E. Co.; No. 2,092,070, tone control, P. F. G. Holst; No. 2,069,869, automatic tone control, Jacob Yolles; No. 2,085,196, selectivity control system, W. R. Koch; No. 2,088,229, automatic fidelity control, R. A. Braden to RCA; No. 2,090,538, variable band coupling device for superheterodyne, H. J. Lyman, Philco; No. 2,091,134, G. L. Beers, Westinghouse, automatic fidelity control, filed 1929, 30 claims; No. 2,078,077, L. C. Hollands, RCA, automatic fidelity control. This circuit involves an i-f amplifier having a band pass characteristic designed to pass a maximum band of 12 kc. at 90 per cent of the resonance value, a second detector and a following second i-f amplifier tuned to a frequency substantially less than the frequency of the first and passing a band width of 4 kc. at 90 per cent of resonance. No. 2,077,466, automatic volume expander, John F. Dreyer; No. 2,078,762, automatic tone control, P. F. G. Holst; No. 2,094,073, tone control system, V. D. Landon; No. 2,083,232, automatic selectivity control, W. R. Koch; No. 2,054,892, automatic fidelity control, R. A. Braden, all to RCA.

Tuning Systems

Remote control. No. 2,091,681, E. B. Hansell, New York, N. Y.

Tuning apparatus. Clock-controlled mechanism. A. A. Thomas, RCA. No. 2,097,901.



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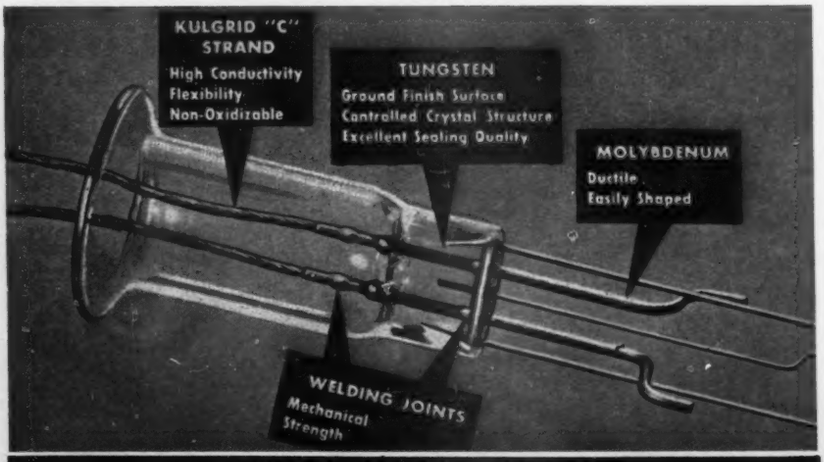
ALLIANCE MFG. CO.—ALLIANCE, OHIO



HARD GLASS STEM
MADE WITH
CALLITE LEAD-IN WIRES
of Tungsten • Molybdenum • Kulgrid

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544-39th STREET UNION CITY, N. J.

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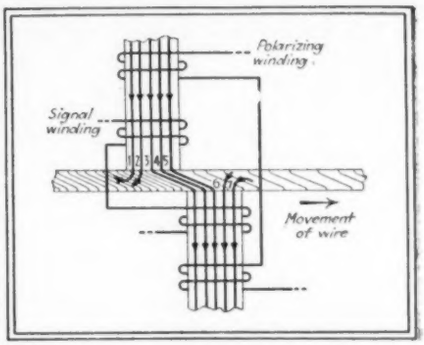

Fig. 1—Cross section of iron wire recording system

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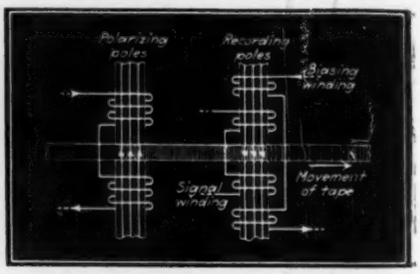


Fig. 2—Cross section of perpendicular magnitization method developed by Bell Laboratories

great enough to produce magnetic saturation of the tape as it passes between these two poles. As the tape moves from the polarizing pole the

(*Continued on page* 58)

tance, the magnetron offers a means of generating larger amounts of power at wave lengths below 100 cm. than can be generated by any other type of vacuum tube generator at the present time. In another mode where the oscillation mechanism depends upon electron transit time, the magnetron offers a means of generating the shortest continuous radio waves.

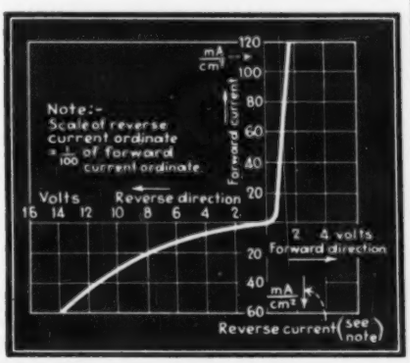
"The negative resistance magnetron is particularly useful in the range of wave lengths extending roughly from 100 cm. to 30 cm. Radiation cooled tubes of this type are capable of generating power of the order of 50 watts at a wave length of 50 cm., and special water cooled tubes can deliver more than 100 watts output at the same wave length.

"The transit time magnetron is useful in generating high frequency currents at wave lengths below 30 cm. Power output of a few watts can be generated at wave lengths around 10 cm. and dependable currents can be generated at wave lengths as short as a few millimeters."

• • •

Selenium Rectifier

FOR MANY YEARS the variation of resistance of selenium as a function of the impinging light flux has been known and has been utilized in a number of electro-optical applications. The use of selenium as a power rectifier is a more recent development but is rather thoroughly covered in the article "The Selenium Rectifier" by Erich Kipphan in the July issue of *Electrical Communication*, issued by the International Standard Electric Corp.



Selenium rectifiers were first used for charging storage batteries but were later used to supply direct current from the a-c main without the use of an intermediate battery. They have also been used to supply power for electro-acoustic systems, electroplating, or welding applications. They may also be used as spark quenchers for industrial circuits, for instrument rectifiers, as well as for detectors in high frequency work.

The article by Dr. Kipphan gives some rather complete curves and technical characteristics of selenium rectifiers and discusses the use of these rectifiers for various industrial applications.

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(Illustration shows just a few representative types of Shields—one of the many classes of tube parts)

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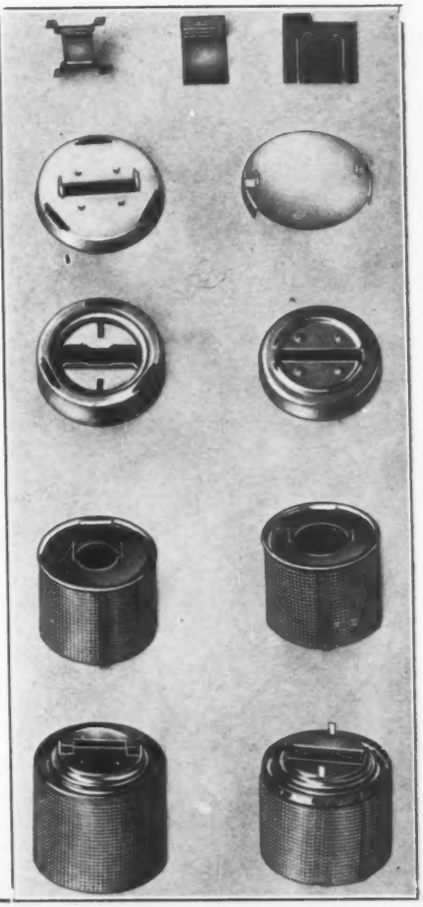

ATTENUATORS

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Designed for use with Weston O Level DB meter. Gives a range of 0 to 40 db. attenuation. Impedance output—5,000 ohms. All resistors non-inductively wound with Constantan Alloy and held to within 1/10%.
Designed for ruggedness and smooth operation. Shaft lubricated with a permanent non-freezing graphite compound.
Standard sizes: 0 to +40, 5,000 ohms; —10 to +30, 5,000 ohms; —10 to +30, 1,500 ohms. Special types made to order.
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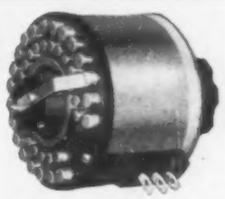

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Can-type Pads
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MODEL 2-A
A 12 milliwatt, D. C., semi-sensitive instrument for general electronic and industrial uses.
Controls 150 watts, noninductive load, at 115 volts, A. C., on single-pole double-throw silver contacts.

	List Price
With coil resistances up to 2,000 ohms	$5.00
With higher coil resistances	5.50

MODEL M
Embodies Tobe Mu-Switch. Input, 50 milliwatts, D. C., Controls 1 kilowatt, noninductive load, at 115 volts, A. C., on single-pole double-throw contacts.

	List Price
With coil resistances up to 2,000 ohms	$7.00
With higher resistances	7.50

Both models are mounted on 5-prong base to plug into standard tube socket.

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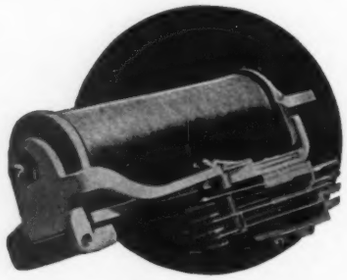

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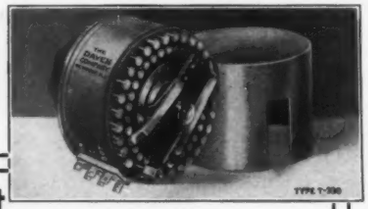

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It is perfect as a mixer and a master gain control for low-level mixing. The new Attenuator has zero insertion loss, constant impedance both in and out of all settings and at all frequencies within the desired range, and the lowest attainable noise level.

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Laminated positive wiping type switch
Low noise level. Below—130 Db.
Shielded from electrical disturbances
Rugged—light weight

Size only 2¾" diameter by 2 1/16" in depth
Zero insertion loss
Frequency error: None over the range of 30 to 17,000 Cps.
Resistors, unifilar wound. Price $17.50

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Filament Rheostats	Volume Indicators	Multipliers	Resistances
Mixer Panels	Output Meters	Super Davohms	Davohms
		Laboratory Equipment	

(*Continued from page* 56)

magnetic force is reduced until, at a sufficient distance from the polarizing pole piece it is zero and the tape has only the residual flux density.

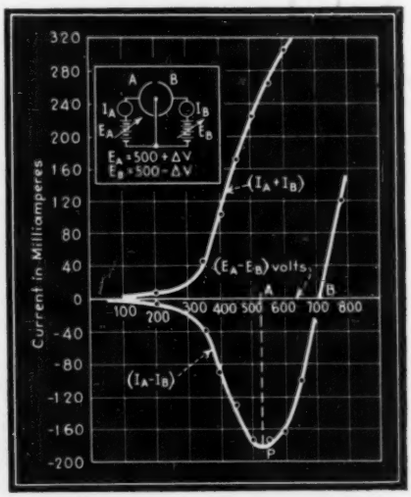
The bias windings on the recording magnets provide a magnetizing force opposite that of the polarizing magnet. The function of the bias winding is to demagnetize the wire strips in the absence of signal current flowing through the signal windings. In the presence of a signal the relation between the magnetizing force due to the current through the signal winding and the flux density is approximately linear so that distortion is minimized. With a constant tape speed, the rate of change in magnetization is proportional to the frequency of the recorded signal. Consequently, the response for a given signal voltage increases directly with the frequency, up to the point where the width of the pole faces approaches a full wave-length of the recorded sound after which the response falls off rapidly. The uncorrected frequency response curve of such a system is not very satisfactory and equalization is necessary to produce a curve which is sensibly flat between 100 and about 7,000 cycles per second.

• • •

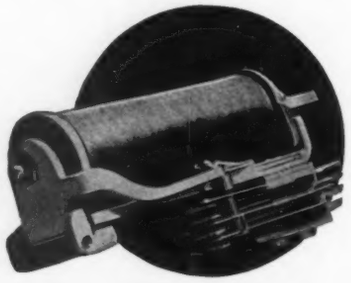
High Frequency Magnetron Generators

IN A PAPER "The Magnetron as a High Frequency Generator" appearing in the October issue of the *Journal of Applied Physics*, a survey of the various types of magnetron generators is made by G. R. Kilgore with particular reference to their performance and limitations at ultra high frequencies.

After giving in some detail the various types of magnetron generators which may be used in the ultra high frequency region, and outlining some of the limitations of circuit and power output, the author concludes: "In one mode of operation where the oscillations depend on a static negative resis-



AUTOMATIC ELECTRIC



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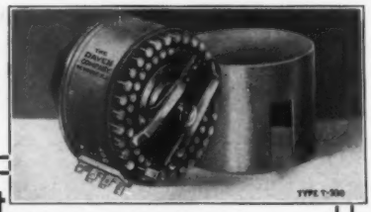

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(*Continued from page* 56)

magnetic force is reduced until, at a sufficient distance from the polarizing pole piece it is zero and the tape has only the residual flux density.

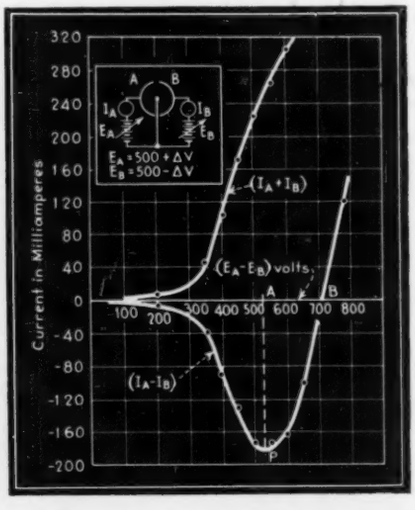
The bias windings on the recording magnets provide a magnetizing force opposite that of the polarizing magnet. The function of the bias winding is to demagnetize the wire strips in the absence of signal current flowing through the signal windings. In the presence of a signal the relation between the magnetizing force due to the current through the signal winding and the flux density is approximately linear so that distortion is minimized. With a constant tape speed, the rate of change in magnetization is proportional to the frequency of the recorded signal. Consequently, the response for a given signal voltage increases directly with the frequency, up to the point where the width of the pole faces approaches a full wave-length of the recorded sound after which the response falls off rapidly. The uncorrected frequency response curve of such a system is not very satisfactory and equalization is necessary to produce a curve which is sensibly flat between 100 and about 7,000 cycles per second.

• • •

High Frequency Magnetron Generators

IN A PAPER "The Magnetron as a High Frequency Generator" appearing in the October issue of the *Journal of Applied Physics*, a survey of the various types of magnetron generators is made by G. R. Kilgore with particular reference to their performance and limitations at ultra high frequencies.

After giving in some detail the various types of magnetron generators which may be used in the ultra high frequency region, and outlining some of the limitations of circuit and power output, the author concludes: "In one mode of operation where the oscillations depend on a static negative resis-



tance, the magnetron offers a means of generating larger amounts of power at wave lengths below 100 cm. than can be generated by any other type of vacuum tube generator at the present time. In another mode where the oscillation mechanism depends upon electron transit time, the magnetron offers a means of generating the shortest continuous radio waves.

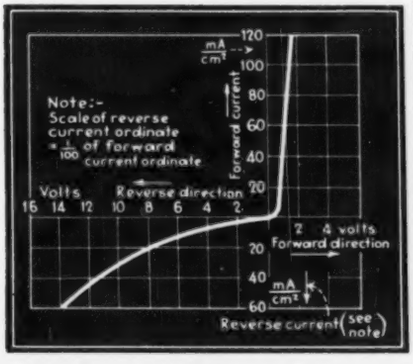
"The negative resistance magnetron is particularly useful in the range of wave lengths extending roughly from 100 cm. to 30 cm. Radiation cooled tubes of this type are capable of generating power of the order of 50 watts at a wave length of 50 cm., and special water cooled tubes can deliver more than 100 watts output at the same wave length.

"The transit time magnetron is useful in generating high frequency currents at wave lengths below 30 cm. Power output of a few watts can be generated at wave lengths around 10 cm. and dependable currents can be generated at wave lengths as short as a few millimeters."

• • •

Selenium Rectifier

FOR MANY YEARS the variation of resistance of selenium as a function of the impinging light flux has been known and has been utilized in a number of electro-optical applications. The use of selenium as a power rectifier is a more recent development but is rather thoroughly covered in the article "The Selenium Rectifier" by Erich Kipphan in the July issue of *Electrical Communication*, issued by the International Standard Electric Corp.



Selenium rectifiers were first used for charging storage batteries but were later used to supply direct current from the a-c main without the use of an intermediate battery. They have also been used to supply power for electro-acoustic systems, electroplating, or welding applications. They may also be used as spark quenchers for industrial circuits, for instrument rectifiers, as well as for detectors in high frequency work.

The article by Dr. Kipphan gives some rather complete curves and technical characteristics of selenium rectifiers and discusses the use of these rectifiers for various industrial applications.

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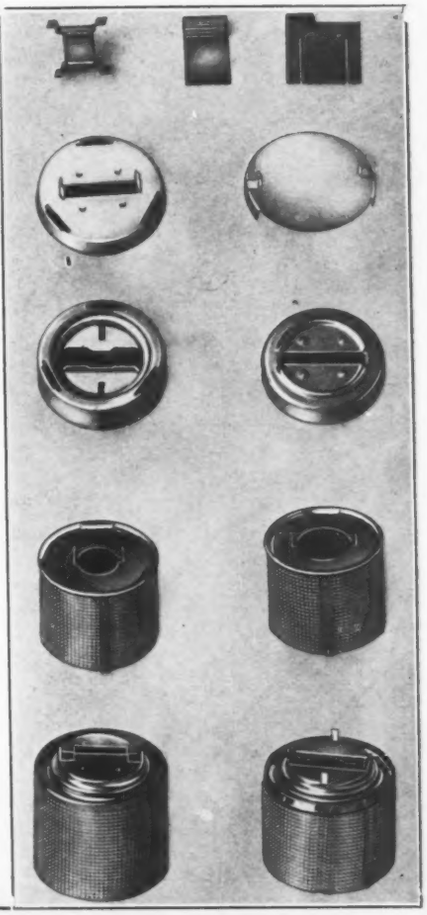

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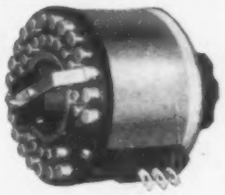

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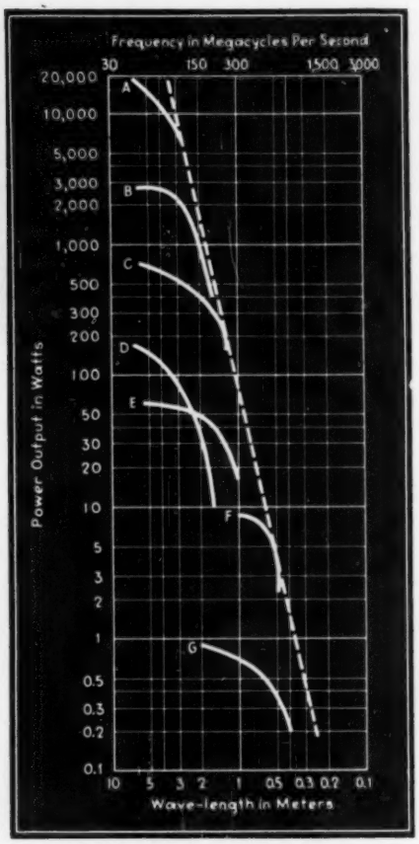
• • •

Triodes Operated at High Frequencies

SOME OF THE FUNDAMENTAL limitations which appear at ultra high frequencies with negative grid three element tubes used as oscillators or power amplifiers are discussed by A. L. Samuel in the October issue of the *Journal of Applied Physics* under the title "Extending the Frequency Range of the Negative Grid Tube."

Although Barkhausen and magnetron tubes are finding extensive use in the ultra high frequency range as oscillators, amplification which is possible with the triode, together with ease of modulation and the improvements in design of high frequency triodes and similar negative grid tubes, leads the author to conclude that the negative grid tube will be able to meet the demands of the circuit designer for some time to come.



Power output versus wavelength for a number of commercially available and experimental tubes. All tubes show a sudden decrease in output at a critical frequency. The dotted line shows the present limit of high frequency operation of triodes.

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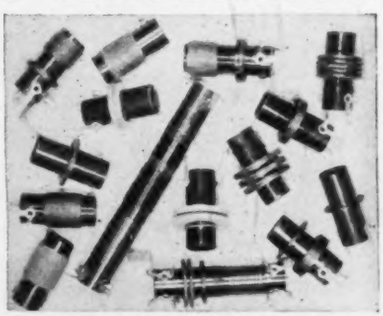

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MANUFACTURING REVIEW

News

✦ According to an announcement made on Nov. 16 by David Sarnoff, president of the Radio Corporation of America, Ralph R. Beal, has been placed in the newly created position of research director of that company. For the past year and one-half Mr. Beal has been supervisor of the RCA television field tests. Mr. Beal's new duties will be to coordinate the activities of the research men in the various RCA subsidiary organizations and to guide all research activities so that there will be no duplication of effort. This step has been made necessary by the extensive research activities of the RCA and its affiliates which are being conducted at Camden and Harrison, N. J., Riverhead, L. I., as well as in various parts of New York City.

The new RCA research director is an alumnus of Leland-Stanford University and has been continuously active in radio engineering since 1912.

✦ Dr. Frederick Bedell, for many years professor of physics at Cornell University, has retired from teaching and will devote himself to research in the electronics field at Cornell as well as in the R. C. Burt Scientific Laboratories at Pasadena, Calif. In the electronics field, Dr. Bedell is perhaps best known for the sweep circuit which bears his name.

✦ In the decorative group of the second Modern Plastics competition which closed October 16, radio cabinets played an important part. A Kadette radio cabinet made of fiberloid by Paul Norris for the International Radio Corporation, of Ann Arbor, Mich., won second prize. Third honorable mention was given to a cabinet made of durez and beetle by the American Insulator Corporation for the Colonial Radio Corporation of Buffalo, N. Y.

✦ The Board of Directors of the Stewart-Warner Corporation declared an extra dividend of 25 cents per share on the capital stock of the Corporation in addition to the regular semi-annual dividend of like amount on October 23. Both were payable December 1 to stockholders on record November 5. At the same time, the Board announced that the consolidated net earnings for the first quarter of 1937 are equivalent to almost 44 cents a share of capital stock, an increase of approximately 6 cents a share over the 38 cents a share earned in a similar period of 1936. Net earnings for the third quarter of the current year amounted to $542,625, as compared with $469,795 for the third quarter of 1936.

✦ Completion of a new assembly plant, fully equipped for the manufacture of heavy industrial transformers has been effected and manufacturing operations are being carried out in it, according to an announcement by the American Transformer Co., 178 Emmett St., Newark, N. J. The new branch factory is at 273-301 Emmett St., Newark, and was built for the purpose of enabling the company to direct more intensive effort on the sale and manufacture of large transformers, including distribution and power transformers.

✦ Immediate construction of a fully modern, air conditioned plant, at a cost exceeding $125,000 is being undertaken by Motiograph, Inc., according to an announcement by Joeeph B. Kleckner, President. The new plant will be located at 4431 West Lake Street, Chicago, where Motiograph will have available complete facilities for the fabrication of amplifiers, horns and sound reproducer heads, and similar equipment. A research laboratory will also be included in the building.

✦ On November 11 Stewart-Warner Corp. announced the purchase of plant No. 2 of the Marmon Motor Car Co. at Indianapolis, Ind. By this purchase, Stewart-Warner acquired 22 acres of land and buildings aggregating 539,000 sq.ft. of floor space. All refrigeration manufacturing operations will be transferred from Chicago to this new plant in Indianapolis.

✦ A dividend of $1 per share, payable to common and preferred stockholders on record as of November 9 was declared by the Board of Directors of the Westinghouse Electric & Mfg. Co. recently. This is the fourth dividend declared this year, bringing the total up to $4 per share. Net income for the nine months was $16,726,520 as compared with $11,123,706, or an increase of 50 per cent over the corresponding period for 1936.

✦ Ellery W. Stone, in charge of the radio telephone and radio telegraph operations of the International Telephone & Telegraph Corporation and its subsidiaries, has been elected vice-president of All America Cables, Inc. Mr. Stone will be in active charge of the radio activities of that company throughout its system as well as of the radio communication activities of other I. T. & T. subsidiaries.

✦ Immediate construction of new broadcast studios for the National Broadcasting Company in Hollywood was recently announced by Lenox R. Lohr, NBC President, replacing modernistic studios erected only two years ago. The new site comprises approximately 5 acres, two city blocks square.

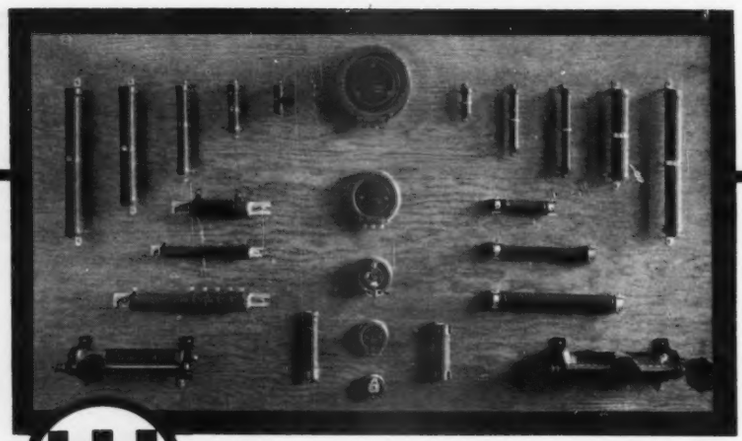
✦ Dr. Paul Dyer Merica, director of research of the International Nickel Company and vice-president of the International Nickel Company of Canada, has been awarded the 1938 John Fritz gold medal, highest of American engineering honors for "important contributions in the development of alloys for industrial uses."

✦ Crowded out of its present quarters in Upper Montclair by the rising volume of business and the positive indication of expanding applications of cathode ray tubes, the Allen B. DuMont Laboratories will move into their own factory building at 2 Main Avenue, Passaic, N. J., about the first of the year.

✦ Organized for the purpose of manufacturing high quality permanent magnet loud speaker units, the University Laboratories have recently opened their offices at 191 Canal Street, New York City. The company is prepared to do repair work as well as to manufacture equipment to order.

✦ Philco celebrated the manufacture of its ten millionth radio receiver by presenting this receiver to the Walter Reed Hospital, in Washington, D. C. on Armistice day. It was given to the veterans in the hospital by the Philco Radio & Television Corp. and presented by Boake Carter, radio news commentator. Replicas of the ten millionth Philco receiver were presented simultaneously with the Armistice Day ceremony at Walter Reed Hospital to the various veterans hospitals throughout the country.

✦ The election of G. A. Throckmorton, as president of RCA Manufacturing Company, Camden, N. J., was recently announced by David Sarnoff, president of RCA and chairman of the board of directors of the Manufacturing Company. Mr. Throckmorton had been executive vice-president of the RCA Manufacturing Company and the operating head following the retirement in April of E. T. Cunningham, former president.



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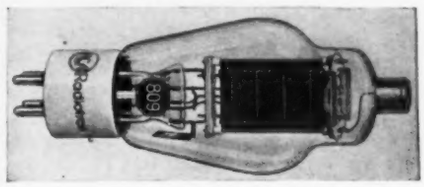

driving power, the RCA Manufacturing Company of Harrison, N. J., announce the type RCA-809 transmitting triode. For class B service, the maximum plate dissipation is 25 watts.

I-F Transformers

A NEW LINE of standard intermediate frequency double tuned transformers has recently been placed on the market by the Meissner Manufacturing Company, Mount Carmel, Ill. Because of the wide range to which these transformers may be tuned, only four types of transformers are required to tune to any frequency from 121 to 650 kilocycles.

Portable Audio System

THE MODEL 108 portable public address system manufactured by the Operadio Manufacturing Company, St. Charles, Ill., is rated at 8 watts normal and 15

watts maximum. It is small, compact and adaptable to practically any use where a public address system is required.

Midget Volume Control

MIDGET VOLUME CONTROLS with 300 deg. effective rotation, and known as the series 37 and 37-F (with switch) have been recently released by the Clarostat Manufacturing Company, Inc., 285 North Sixth Street, Brooklyn, N. Y.

Marine Speakers

ESPECIALLY DESIGNED to operate under adverse weather conditions, such as on ocean-going ships, the marine speaker built by the University Laboratories,

191 Canal Street, New York City, is constructed to conform with the specification required by the Bureau of Marine Inspection and Navigation.

Radio Hardware

A COMPLETE LINE of small hardware assortments, intended for electrical, radio and automotive service shops and for home use by amateur craftsmen, is being brought out by the Insuline Corporation of America, 25 Park Place, New York City.

Loud Speaker System

DEVELOPED TO FILL the need for a superior quality speaker, economically, the Lansing Manufacturing Company, of Los Angeles, Calif., announces its

new Iconic loud speaker system. This system includes a high frequency unit for use up to 10,000 cycles and a multi-cellular horn which gives uniform coverage over an angle of 80 deg.

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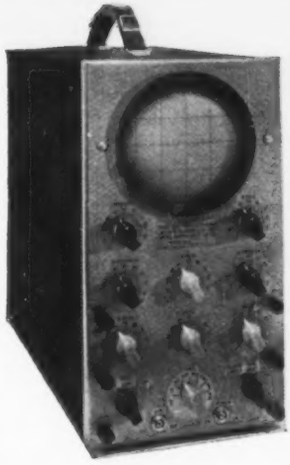

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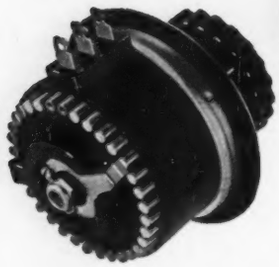

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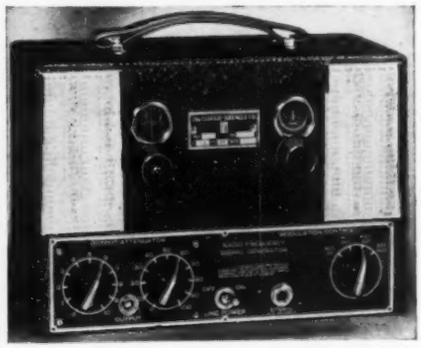

pany of Chicago features a direct-reading scale which may be used on any of the five-bands for which the generator operates.

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Rochester, 1937

(*Continued from page 15*)

due to tight coupling to the a-c source are automatically eliminated in substitution measurements by any resonance method. The errors are usually caused by residual inductance and resistance in the standard condenser (cf. Field and Sinclair, *Proc., I.R.E.*, Feb. 1936).

Vibrational Tube Analysis

A criticism was made by A. B. Oxley, RCA Victor, Canada, of the current method of testing for microphonics in vacuum tube production using the method of striking the tube envelope with a hammer and judging the acceptance limits either by aural or visual indicators. Although such impact tests do produce noise and show up the more flagrant cases of microphonics, the method is one in which the various elements vibrate at their own natural periods.

To investigate the causes of microphonics, as well as to provide a simple production test system which would detect tubes likely to produce trouble in use, a vibrating platform was arranged upon which the tube to be tested was mounted. The platform was vibrated about 0.001 inch by means of a dynamic loud speaker motor fed from a beat frequency oscillator, so that the tube could be vibrated at any audio frequency. The elements were connected to proper voltages and circuits and the plate current was observed as the frequency was varied. Whenever the beat frequency reached a point corresponding to a resonance of one or more of the elements in the tube, the plate current increased sharply. The resonance peaks were recorded on the screen of a cathode ray tube, and by setting upper limits on this screen, tubes could be rejected or accepted in a factory test.

It was found that similar tubes had very similar frequency-resonance patterns, most of whose peaks were very sharp. By connecting various elements, one at a time to the cathode, certain of these peaks disappeared. Those which disappeared were due to the element connected to the cathode. By a process of successive connection-to-cathode, it was

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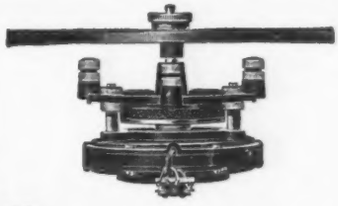

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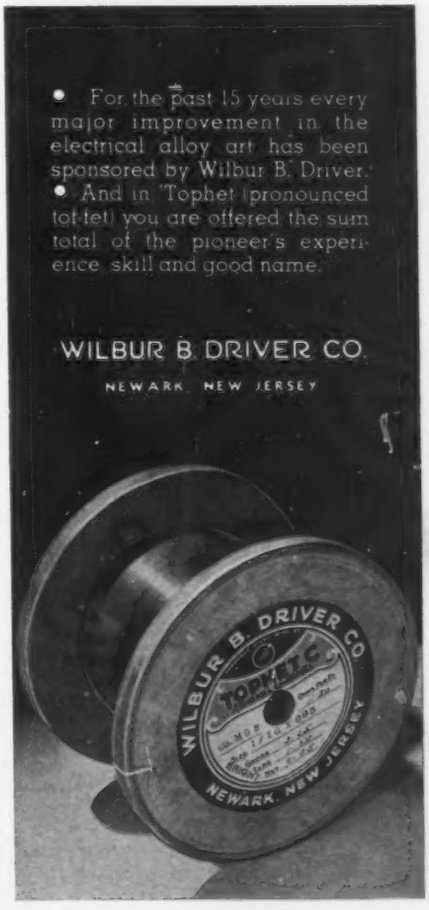
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possible to determine the resonances of all of the essential parts of the tube.

Thomson and Headrick Discuss Electron Beam Focus

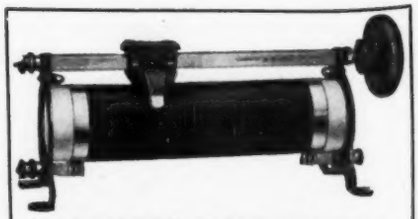
"Space Charge Limitation on the Focus of Electron Beams," delivered by Dr. L. B. Headrick, RCA Radiotron, discussed the effect of space charge on the focussing of beams of both circular and rectangular cross section in vacuum cathode ray tubes. It was shown that with the case of beams of circular cross section, the beam reaches a minimum cross section, is no where perfectly circular, and, beyond the minimum cross section, increases in area more rapidly than distance between the focal point and the screen of the tube. In the case of beams of rectangular cross section, it was shown that the minimum beam width may become zero at a certain distance from the tube, beyond which the width increases.

Negative Ion Components of the Cathode Ray

C. H. Bachman and C. W. Carnahan, Hygrade Sylvania, discussed a study of negative ion components made by using the cathode ray tube as a mass spectrograph. Photographs of the screen of the tube showed, by the deflection of the cathode beam, that there were a considerable number of negative ions within the tube. Those which were definitely or tentatively identified include C, O_2, CH_4, H_2O, H_3O, CN or H_2O_2, N or HCHO, and Ca.

Audio Curve Tracer

An audio frequency curve tracer, using the image formed on the screen of a cathode ray tube for producing the frequency response curve was described by J. B. Sherman, Radiotron. The frequency determining ordinate is a beat frequency oscillator actuated by a relaxation oscillator. The frequency of the b-f oscillator is made proportional (by the use of an a-f-c circuit) to the d-c voltage generated by the relaxation oscillator. As the relaxation and beat frequency oscillators are set going, a trace sweeps across the screen horizontally. The vertical deflection, or amplitude ordinates, are obtained from the



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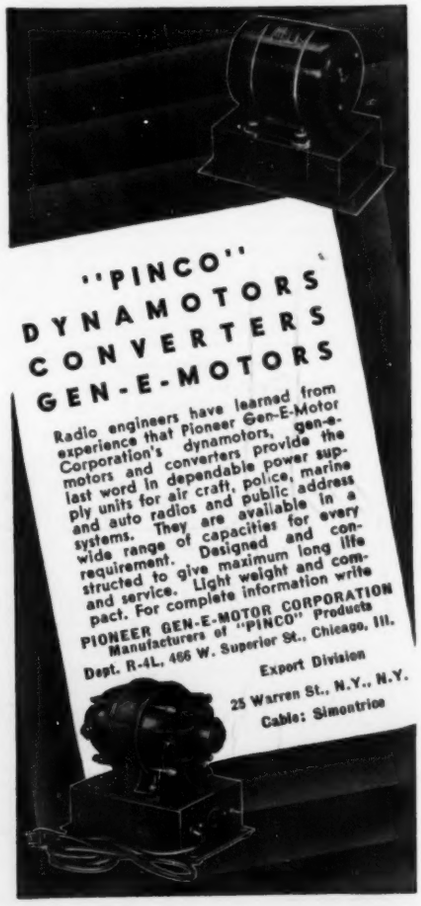
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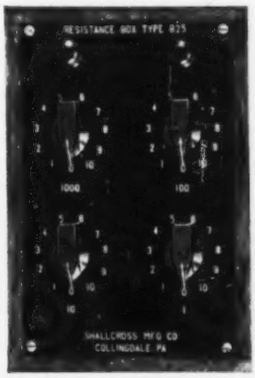

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equipment under test. In the demonstration which was given, the amplitude was determined by a loud speaker, fed by the same beat frequency oscillator as actuated the cathode ray tube beam, and a microphone pick-up. The demonstration showed conclusively the various deep humps and valleys in the loud speaker output which were considerably "ironed out" when the microphone was placed very close to the speaker. A block diagram of the curve trace is given on page 15.

The equipment covered the entire audio frequency range, in either logarithmic or linear fashion, and a method was described in which any portion of the audio frequency spectrum could be expanded at the expense of some other portion, so that for special studies, interest could be given to a portion of the a-f band.

High Efficiency Modulation

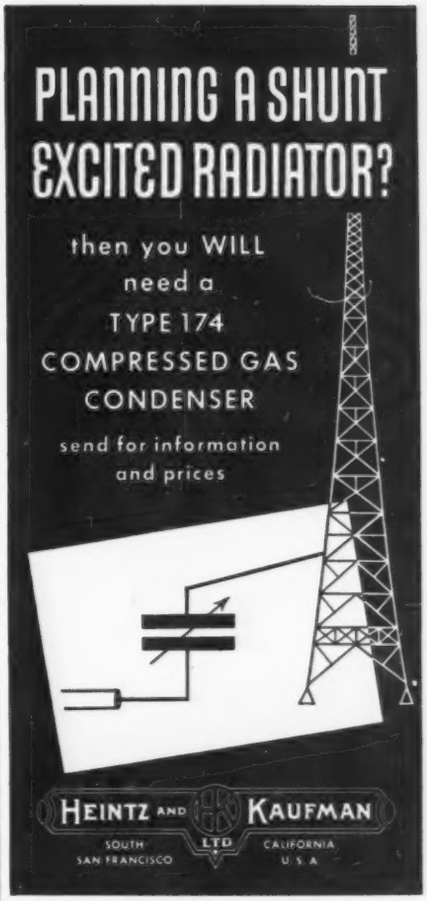
The two methods of modulation discussed at the convention at first sight may seem to be decidedly similar. One, the Parker system described above was developed for the purpose of securing wide bandwidth for television purposes and the other the Dome system, for attaining higher efficiency than prevailing in conventional systems.

R. B. Dome, General Electric, attains high efficiency (of the order of 50 to 60 per cent) in a modulator by modulating both grid and plate. Positive peaks are taken care of by shifting the load line; negative peaks by modulating the grid of the output stage.

By an absorption circuit coupled to the antenna circuit, the load line can be changed. The current taken by this absorption circuit is rectified by tubes whose grids are modulated and the rectified current is put back into the power supply system thus reducing the power required. A circuit equivalent to a quarter wavelength line shunts the modulator tubes. This line acts as a variable resistance in effect across the antenna circuit. The total input to a 50 kw. transmitter of this sort would be about 139 kw. A single 2A3 will modulate a 50 watt amplifier by Mr. Dome's system.

Measurements on Auto Antennas

Considerable discussion resulted after the paper by H. Lyman, Philco, on the methods of measuring auto-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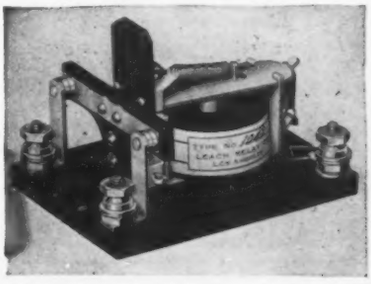

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mobile antennas at the Philco plant. After describing briefly the characteristics of typical car antennas in use at the present time, as well as the past, Mr. Lyman described how he used a vertical rod antenna of fixed dimensions as a comparison antenna. The power factor, effective height, capacity of unknown antennas were compared to this rod which had the dimensions of 32 inches length, 0.3 inches diameter.

Dudley Foster, RCA License Laboratory, in discussion mentioned the fact that if the rod antenna is short compared to a wavelength its effective height is equal to one-half its physical height if erected on and over an infinite ground plane. To simulate this plane, a 24 inch diameter disc around the base of the antenna under test was used.

Several of the papers presented at the convention are to be found in toto in the *RMA Engineer*, Vol. 2 No. 1, and will not be reviewed here to any extent. Thus the paper by A. V. Bedford, "Figure of Merit for Television Performance," "Oscillation Stabilization," by C. E. Grandquist, "Use of Negative Regeneration in Radio Receivers," by C. B. Fisher, may be found in the RMA magazine.

Teledynamic Control

Rochester conventions are noted for stimulating, not to mention occasional startling, innovations. This year's prize went to the RCA License Laboratory for a paper with a high sounding title which meant simply a new and extremely interesting method of remotely controlling a radio receiver—or any other device operating from the power lines.

Essentially the method consists in generating a radio frequency, say 200 or 300 kc. at the remote control point. This signal is sent over the power line to the controlled-receiver point. Here a gaseous tube, with a breakdown voltage of the value of 70 volts, is operated. By a resonant circuit the entire break-down voltage may be secured from the control signal, or by means of a biasing circuit the gas tube may be held continuously somewhat under the breakdown point at all times and merely in readiness to conduct and initiate the control functions when the additional voltage is secured from the control point. Not only can the set be turned on and off but also tuned and its volume regulated remotely.

By means of using either phase of a-c modulation on the carrier, two functions may be performed. If two frequencies and both halves of the cycle are used as many as 10 functions may be carried out. In the actual demonstration 4 relays at the receiver and two frequencies at the control point enabled the operators to turn on and off an a-f-c receiver, control its volume and to tune in as many as 6 stations. With three tubes, 26 functions could be performed.

From the standpoint of domestic amity, however, the new system seems to have certain disadvantages (or advantages). Thus the decision as to who in each household controls the receiver is not settled—the only difference being that the contestants need not both be near the receiver. Thus the lack of single control might be even worse than under present conditions. If one member wants jazz and another opera, or one prefers loud noises while the other wishes to be lulled to sleep with all-bass cosmetic bands, strife under the teledynamic system may be just as bad as under the present grab-the-dial-yourself system.

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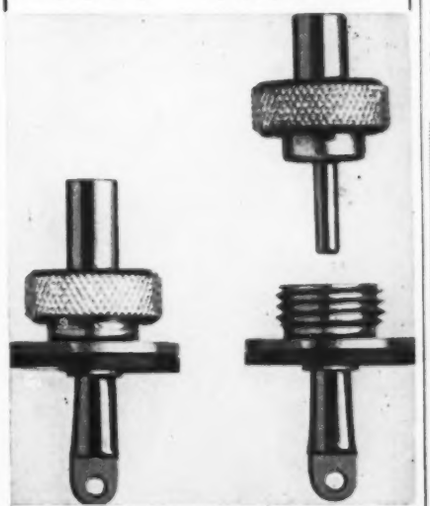

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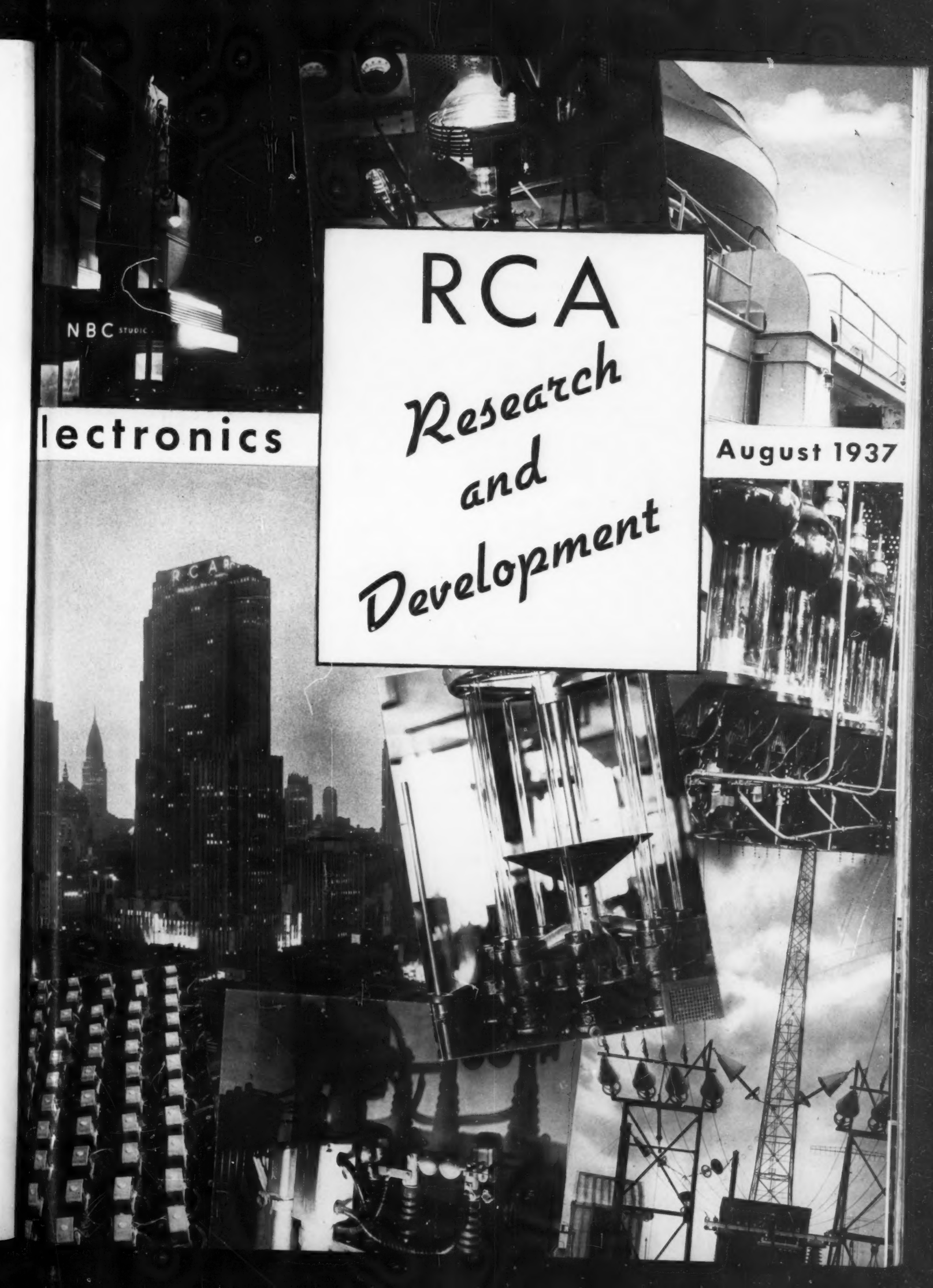
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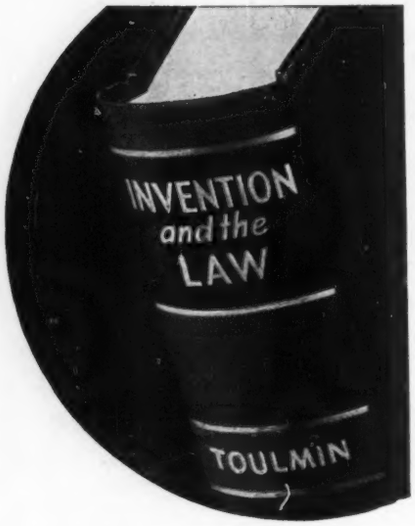

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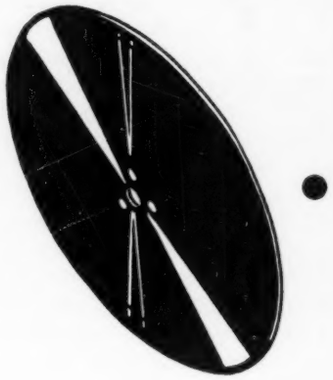

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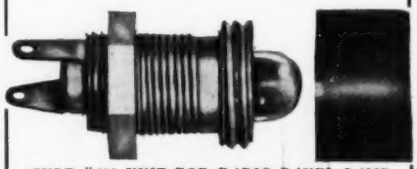

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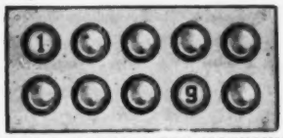

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Remotely controlled swivel antenna at Riverhead, used in ultra-high frequency studies

duced—all fit into that early vision of an American communication system, but in a fascinating and composite way that could not be foreseen by those who were in at the start.

HISTORY

When RCA "took over" the assets of the Marconi Wireless Telegraph Company of America existing in this country, it inherited a factory at Roselle Park, N. J., where marine communication apparatus was made. It also inherited some good men with the factory; men whose jobs were research and development. Among them were H. Shoemaker, Roy Weagant and F. H. Kroger, the last of whom pioneered in engineering then, and has been in the forefront of radio experimentation since 1902. Today he uses his days and his imagination at Rocky Point, Long Island, working on projects 2 to 5 years in advance of their practical application. He makes no secret of the fact that at present his time is being spent on schemes involving wavelengths of fractions of a centimeter.

The Roselle Park plant was closed in 1920, and the men who experimented there moved, some to the site of RCA's projected trans-atlantic station on Long Island, and some to quarters at 326 Broadway, New York, where marine commercial and technical activities were continued. C. H. Taylor, from the Marion, Mass., station of the Marconi Company joined the group on Long Island. Mr. Taylor had come to this country in 1902, to participate in the struggle to send radio signals across the Atlantic with reliability. None has a better right to look with satisfaction upon present achievements than he, because he has had an active part in forcing stubborn space to yield before relentless investigation. And yet if you call upon him at his office today you may find him poring over reports of the effects of recent sun spots on short wave transmission. It is not enough that continuous communication is now an assured fact; today the job is to insure that nothing shall interfere with communication at accustomed speeds.

The first laboratory set up by RCA was housed in a tent, erected late in 1919 at Riverhead, Long Island, the site of the company's projected receiving center. Under this canvas H. H. Beverage, now Chief Research Engineer of R.C.A. Communications (1937 President of the Institute of Radio Engineers) inaugurated a program of field research in radio reception. Beverage had served with Alexanderson in General Electric. In 1920, activities were transferred to a little white shack, fifteen feet square. This was later enlarged, and the work here was augmented by another laboratory established at Belmar, N. J., in one of the buildings acquired from the predecessor Marconi Company.

During the World War, the best reception point was located in Maine. It was decided therefore to explore possibilities of this location for commercial operation. The company proposed to relay transatlantic signals received in Maine to New York by radio rather than by wire. Transmission was to be accomplished on wavelengths of about 1600 meters.

H. O. Petersen and H. H. Beverage with field strength measuring set, a Radiola and the first h-f signal generator in a wash boiler

RCA

Research and Development

Communication—broadcast or directed, by voice or music or code or sight, on film, or by facsimile—is an art based on and maintained by research, by exploration into new methods, new processes, new materials, new mathematics, new concepts. The millions of words that cross the seas in code, the thousands of hours of entertainment and education for millions of listeners, the ship-to-shore system, communication between land and aircraft or with land vehicles—all hinge upon continued research. Radio Corporation of America plays a major role in this dramatic art of communication; its research and development activities are told in the following pages by the editors of *Electronics*.

IT is romantic but true, that the Radio Corporation of America, the outstanding example of private enterprise in the radio and electronic arts, was formed at the suggestion —even persuasive insistence—of officials of the United States Government. At the end of the Great War overseas communication with the United States was largely dominated by foreign capital. The only facilities bearing any semblance to a commercial international system were owned by the Marconi Company. The Navy Department, with an eye to a possible future situation in which this foreign control might place commercial opportunity above public welfare, saw the chance to develop an American system.

The opportunity that presented itself was the proposed sale of the Alexanderson alternator to the British Marconi Company by the General Electric Company, which had developed it. General Electric had practically no other purchaser—certainly no American buyer. And yet, at that time, it was the most promising single piece of apparatus which would make possible transoceanic communication through space, and could thus offer a service in competition with, and independent of, underwater cables.

So, on April 4, 1919, the Acting Secretary of the Navy, requested the General Electric Company to hold up its negotiations for the sale of the alternator until a conference with the Navy might take place. Out of this round table discussion came the Radio Corporation of America. The new company thus formed had for its premises that the United States should possess its own communication system, and that this should be realized from the practical opportunity the Alexanderson alternator, together with the multiple tuned antenna, offered. The entire history of RCA since that time has been based on the same two premises—to perform a service, and to develop technical equipment to improve and expand that service.

First RCA laboratory, Spring 1920. H. H. Beverage, H. L. Olsen, Chester Rice, E. W. Kellogg, R. D. Greenman

The commercial side of this picture has been told many times. The early history of the company has been cited as an early instance of governmental participation in business, because for a while representatives of the Government sat in on meetings of the Board of Directors. The financial background of the company has been told at length in an article in the September, 1932, issue of *Fortune*. But the real background of the company is not finance, nor the commercial give-and-take of business, but *technical organization*. The story of this part of the company's activity has not been told, except in fragmentary form. *Electronics* presents, therefore, this story of the research and development activities of RCA. The laboratories and their products, the men who man them the achievements that have been pro-

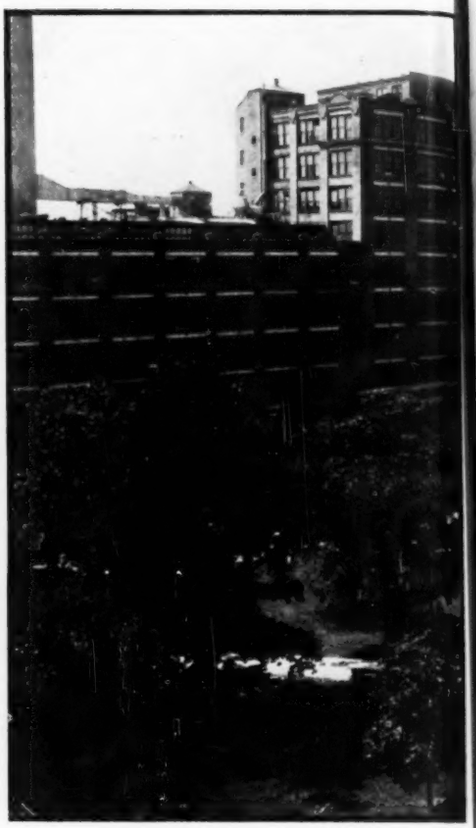
It probably is remembered only by those who were actively engaged in this work that Belfast, Maine, was the station at which automatic radio relay and multiplex radio transmission were first achieved. On a single carrier, five separate channels carrying signals received from Europe were imposed, to be unscrambled at Riverhead into their original compoents. At about this time, C. W. Hansell took the fundamental work with crystals of W. G. Cady, of Wesleyan University, and G. W. Pierce of Harvard, and applied it to create the first crystal-controlled radio transmitter. The staff at Belfast found time, between jobs, to accomplish the first successful international program, which was received from London and automatically relayed by radio to New York, for broadcast over station WJZ. This occurred in December of 1924.

After many months of commercial operation at Belfast it was concluded that it would be more effective to work with longer transatlantic circuits, to gain the convenience of having the point of reception close to the operating terminal at New York City. Accordingly, activities in transatlantic communication were consolidated at Long Island. Here H. H. Beverage, H. O. Peterson, C. W. Hansell, J. L. Finch, P. S. Carter and N. E. Lindenblad continued their feud with 2,000 miles of ocean, under the veteran C. H. Taylor.

Evidence of the effectiveness of this organized approach to a commercial, international radiotelegraph service is that, at the end of 1920, the first year of RCA operations, radio circuits had been established with England, France Germany, Norway, Hawaii and Japan. These facilities included 300 KW stations, 400 foot towers and other gargantuan items. Today, the complete RCA international system is comprised of 55 circuits which link the United States, its insular territories and the Philippines directly with 45 countries. Nowadays the bulk of the traffic is carried on short-wave channels, using much less bulky, and more effective transmitters and antennas.

Transoceanic radio circuits were not the sole interest of RCA. The assets of the American Marconi Company acquired by RCA upon its organization included ship stations of American registry and shore stations on American mainland. It was the most profitable part of the company's business. It deserved technical attention. Therefore the benefits of continued engineering in long distance communication spread into this field, and ships began to receive better equipment. Crystal detectors gave way to vacuum tubes, and spark and arc transmitters gave way to tube equipment. Efforts in this latter direction were met with some resistance from potential users, however, because vacuum tubes were things of glass, with delicate internal elements, and therefore too fragile to be trusted to operate satisfactorily when subjected to a ship's vibration, or to the possibility of breakage when they might be most needed, in emergency. Despite these objections the last RCA spark transmitters were made in 1922.

In 1924 engineers of the company produced the first practical, commercial, rotating-loop type, radio direction finder. This important aid to navigation has since been under continued improvement.



Prior to 1920 efforts toward radio development were for the most part directed to improvement of point-to-point and marine communication. But in that year something happened in Pittsburgh. Frank Conrad of Westinghouse put the baseball scores on the air by voice, discovered that thousands of people would listen on home made receivers,—and broadcasting was born. Later that same year C. W. Horn joined in this new field, becoming manager of radio operations, and technical boss of famous KDKA. Mr. Horn (Charlie to most people) is now Director of Research and Development of NBC.

The beginnings of broadcasting in America (1920) presented problems in the design of transmitting equipment which were far different from those of long-range, point-to-point radiotelegraph communication. For a time, RCA's requirements in laboratory work relating to this new field were met by Dr. A. N. Goldsmith and his assistants, at the College of the City of New York. Dr. Goldsmith had been retained since the Marconi Company days, as consultant, and his laboratory staff

90 megacycle "boiler" transmitter under construction at Rocky Point. At full load the shield gets hot, so air-cooling is used

RCA-Victor plant at Camden. Ground space, 82 acres, floor space 480 acres, 14,000 employees maximum, power plant, 41,500 kw., 50,000 tons coal consumed annually.

had originated many important advances in the communications field. Among these was the development of the centralized high-speed ink recorder system, in 1921, which replaced the aural recording system inaugurated by the British Marconi Company. In this system the signals are recorded on a paper tape and transcribed on typewriters by groups of operators.

By 1924 it was apparent, however, that the full time of this staff would be required, in quarters specially prepared for their needs. In that year the company set up a new laboratory at the edge of Van Cortlandt Park, in New York City, to which the group moved.

The laboratory's activities in two groups were under Dr. Goldsmith. One, the Research Division, was headed by Julius Weinberger, and the other, the Engineering Division, was headed by Arthur F. Van Dyck; both now of the License Laboratory. These groups supplied specifications for broadcast transmitters and receivers, conducted field surveys for the buyers of broadcasting equipment, and supervised the design and construction of the first broadcasting stations, and carried on continuous quality control testing of all sets and tubes sold by RCA. From their work came many devices which were important in advancing the art, including the first electric phonographs, many fundamental acoustical developments, the velocity microphone, centralized radio, the first low-priced a-c receivers using the 226 tube, measurement methods, early sound motion picture devices and a television system giving theatre-size pictures.

The years 1929 and 1930 were important times, for it was then that the company acquired manufacturing rights and manufacturing facilities. With the purchase of the Victor Talking Machine Company in 1929, it was set up to manufacture home receivers and radio equipment of all types. In 1930 the purchase of a plant of the General Electric Company at Harrison, N. J., equipped it to enter the tube manufacturing field. This plant was an outgrowth of the first incandescent lamp factory of Thomas A. Edison.

Beyond the attainment of these objectives, RCA gained also a large complement of additional laboratory man-power. It was logical that future laboratory activities be concentrated at the Camden and Harrison plants. Accordingly the Van Cortlandt Park Laboratory was closed, and its staff moved to one of the locations in New Jersey.

In 1930 there was established a laboratory maintained as a service to licensees. RCA has been rendering such service since 1928 from the laboratories which were also doing the company's other research work. By 1930, this license service had grown to an activity requiring a separate technical group, organized to render engineering service on a more comprehensive scale to its patent users. The License Laboratory was first established at 75 Varick Street, but later, in the spring of 1935, was moved to its present quarters at 711 Fifth Avenue, New York.

RCA's laboratory facilities have grown as adjuncts to the various services of the company. For this reason they are not consolidated at any one place, but are located convenient to the various activities. These services may be divided into four general classifications: Communication, Manufacturing, Broadcasting and Licensing.

RCA COMMUNICATIONS LABORATORIES

Communications, from which the radio industry sprang, is overshadowed by broadcasting in public interest, but it has never ceased to be the vital factor in pressing engineers and research men on toward greater knowledge. Not only must apparatus be developed, but Nature herself must be investigated to know best how to circumvent and to take advantage of the vagaries of weather, and such seemingly unrelated phenomena as the spots on the sun, and the ionization of the upper air.

Communications research activities divide broadly into three divisions, Transmission, Reception and Terminal Equipment. The work of these groups is co-ordinated under H. H. Beverage, Chief Research Engineer, who in turn reports to C. H. Taylor, Vice President in Charge of Engineering.

Transmission

The transmission laboratory, under C. W. Hansell, is located at Rocky Point, L. I., adjoining the commer-

cial-transoceanic radio facilities. Its function is to develop new and more efficient types of transmitters and antennas for frequencies used in transoceanic communication and for frequencies higher than those employed in such work and for the study of propagation in portions of the radio spectrum not now in general use.

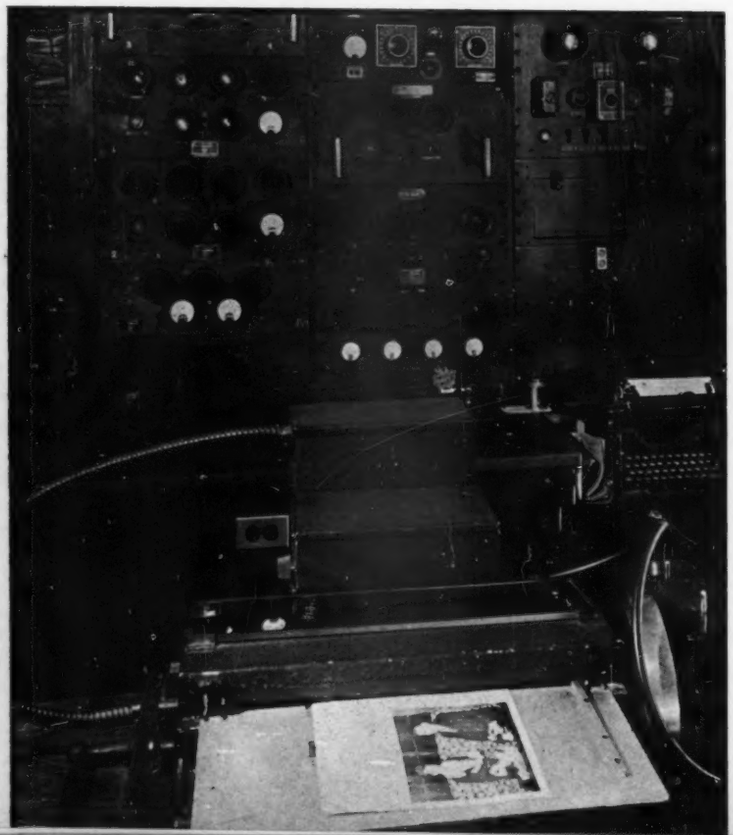
There is continual search for transmitters of greater stability and power, in the simplest and most economical designs. In the early attempts at creating short wave transmitters of considerable power great difficulty was encountered in preventing self oscillation between the various stages. This problem was solved by making the successively higher powered stages multiply the frequency, in addition to amplifying power. The arrangement was so successful that it was rapidly adopted for use in short wave communication throughout the world.

In 1927 the Transmitting Division developed the first four-tube power amplifier, which held the world's record for the highest high-frequency power on a given frequency for several years. In 1927, also the first quick wave change device was developed, almost doubling the value of the individual transmitter by fitting it for day or night service. More recently, the same principles, employing newer tubes and associated components, have been applied to create a transmitter with an output of 200 kilowatts—the highest unit output in short waves today.

Magnetron research at Harrison

Frequently it is found that principles and equipment successfully employed in one radio band hold little promise of adaption to even experimental work in another. An example of this is in crystal control of transmitters. Experimental work with ultra-short waves soon demonstrated that as the frequency was increased the crystal method of controlling transmitters became more and more cumbersome and expensive. Crystals have definite, practical, upper frequency limits, beyond which an excessive number of multiplier stages becomes necessary in ultra-short wave work. To obviate this necessity the transmission laboratory developed the principle of resonant line control. This consists, basically, of a concentric transmission line a quarter wavelength long—a device of extremely low loss, comparable to a crystal and yet capable of controlling the transmitter directly, without use of crystal or multipliers.

Harking back to the reason for



Facsimile equipment control board at 66 Broad Street, New York

founding the company—so that America could have its own radio communication system—it is interesting to note how antenna development made its contribution to this end. In fact, improvements in antenna design made the system possible economically. Commencing with complicated and expensive arrays, it was seen that a multiplicity of such antennas, for simultaneous communication with several countries, would result in prohibitive plant and maintenance cost. The necessity for more economical antenna designs, of simpler mechanisms, was obvious. Subsequent mathematical and theoretical exploration pointed to the possibilities of obtaining desired performance from antennas of radically different design. Thus the Transmitting Division came to develop various types of "long wire" radiators, each successive type representing an advance both in efficiency and economy of construction and maintenance over preceding efforts. Today's antennas produce a concentration of power in the desired direction equal to that of the older arrays at the cost of about five to ten per cent of the earlier method.

The application of directive transmission is illustrated by an incident during the course of Admiral Byrd's last voyage to the Antarctic, when it was desired to send a special radio program to his ship by way of Rocky Point. According to the itinerary, the *Jacob Ruppert* should have been off the coast of Ecuador, so transmission was attempted with an antenna directed on South America. When it was found that the vessel was in mid-Pacific instead, and outside that antenna's beam, the engineers hastily went into conference with a terrestrial globe.

The difficulty was solved by reversing the Moscow antenna electrically, and the radio waves from Rocky Point played upon the ship like the searchlight of a passing vessel. Today's directional transmission is a far cry from the splash of energy sent off in all directions in the ethereal mill-pond by the early spark transmitters.

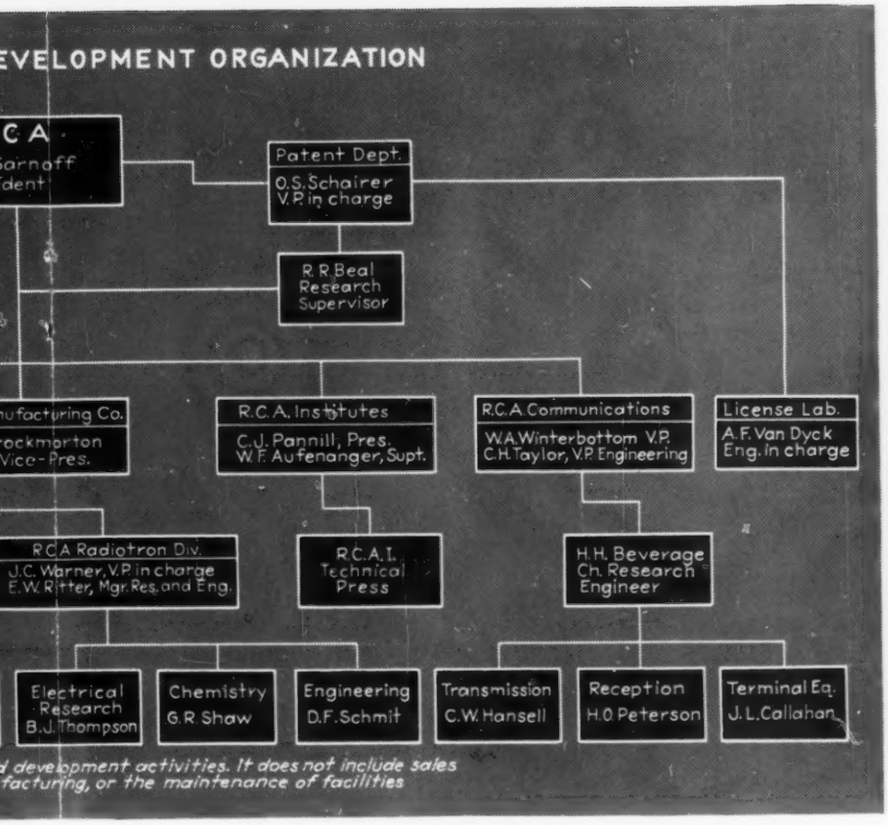
Reception Division

The Reception Division is located at the main receiving center, at Riverhead, L. I., under the direction of H. O. Peterson. It is engaged in the development of transoceanic receiving facilities which involves not only the improvement of receiving equipment but also the continuous study of the propagation of electrical energy through space. The work is not confined to the frequencies utilized for transoceanic communications but extends also into the ultra-high frequency domain.

The most important early contribution of this receiving laboratory was the "wave antenna" for long wave reception developed by Beverage, Rice and Kellogg. This was the first time the aperiodic principle was used in reception by which an antenna of fixed dimensions receives a wide band of frequencies with equal efficiency. Nothing looked less like the antennas then existing. The wave antenna was strung on telephone poles, not over 20 feet from the ground. This line of poles was aimed in the general direction of the countries from which signals were to be received—and the wires on these poles were actually grounded at the remote end. Later, when the laboratory became active in investigation of short wave phenomena, H. O. Peterson designed the "fish-bone" type, which is standard in RCA communications practice at present.

Propagation studies with "fading" on short waves led to experiments in combining the products of signals received at different frequencies, as well as the products of horizontally and vertically polarized waves. Still another method, known as "spaced diversity" reception, utilized three antennas in triangular formation spaced about a thousand feet apart. These were of the "fish-bone" type, for reception of horizontally polarized waves, the energy from each being fed to its own receiver. The combination of the products of the receivers provides signals unusually free from fading difficulties. However, there remained problems of mutual interference between receivers, which necessitated the development of tuned radio frequency amplifiers for operation on much

Balloon ascensions at Riverhead determine "angle of arrival" of radio waves



F. E. Mullen, Director of Information, RCA; H. H. Beverage, RCA Communications; J. C. Warner, Radiotron; W. S. Fitzpatrick, Secretary to the Board; and A. F. Van Dyck, License Lab. Members not present: (above, left to right), C. H. Taylor, RCA Communications, R. R. Beal, Research Supervisor, RCA; O. B. Hanson, NBC; C. B. Joliffe, RCA Frequency Bureau.

the preparation of messages for actual transmission, i.e., transcribing or converting printed text into time codes or the equivalent thereof, and on the receiving end to transcribe electrical pulses into a form of language message for delivery to the addressee.

This general activity divides into three classes: Research and advanced engineering, application engineering and construction engineering. The principal projects of this group are with general radiotelegraph control apparatus, which includes automatic tape transmitters, tape perforators, tone sources, tone keyers, line filters and equalizers, line amplifiers and ink recorders. Upon this fundamental system advanced radiotelegraph applications are based, such as time division multiplex, time code printers and code converters.

Time division multiplex appears to hold great future possibilities in radiotelegraphy because of new horizons of operating efficiency and flexibility which it has already brought into view. It makes possible multiplex transmission at no increase over power necessary for simplex operation and it operates through conventional simplex transmitting and receiving facilities. It offers greatly increased flexibility at the operating terminal by enabling the simultaneous operation of several different classes of radiotelegraph service.

Thus, as the Transmission and Reception Divisions continue to provide better and better radio circuits, the Terminal Equipment Division is constantly developing ways and means for making the most efficient use of the improved facilities.

Other special applications which also employ fundamental telegraphic technique in the operation of facilities for transmitting and receiving intelligence in different forms are picture sending and recording apparatus termed by RCA "Photoradio," and facsimile equipment. The term facsimile is here used to differentiate between the transmission of pictures and sketches and the transmission of written or printed matter.

RCA VICTOR

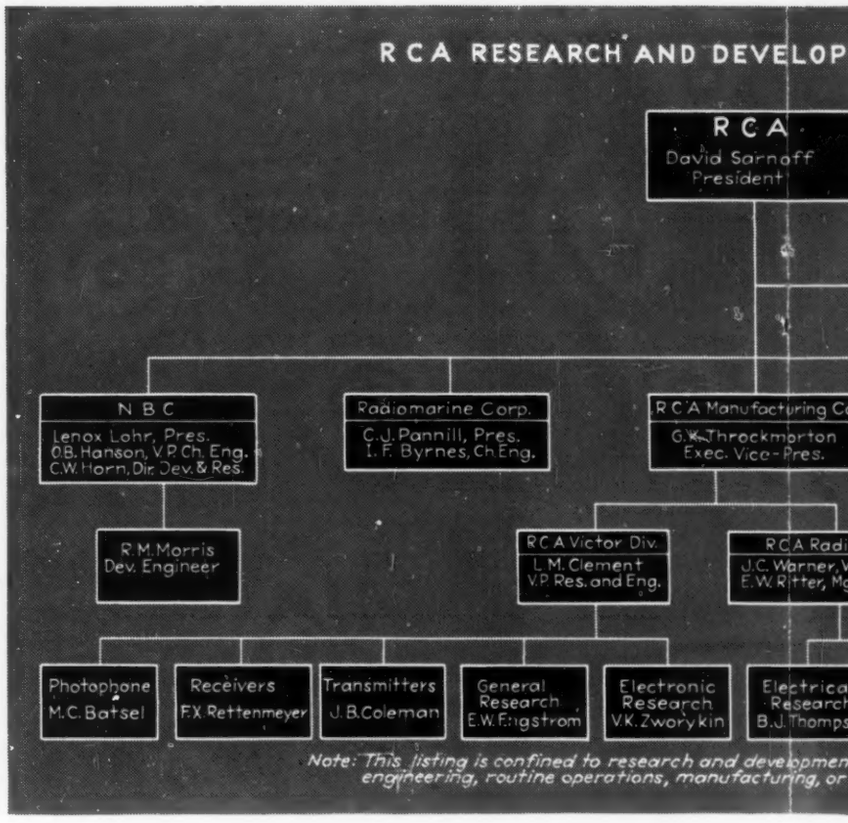
In 1927 RCA began to license other companies to make radio sets under its patents. In this year the Victor Talking Machine Company acquired the Orthophonic phonograph developed by the Bell Telephone Laboratories and began to believe there might be a revival of its business. There was a flurry of public interest, but in a short time business was again "not so good." Radio was taking hold in a big way, cutting seriously into phonograph sales.

At this same time RCA was looking for an opportunity for getting into manufacturing. Logically Radio and Victor should join, in producing instruments for home entertainment —which was the first objective in RCA's manufacturing project. This they did in 1929, and at the beginning of the depression RCA found itself in possession of a large plant.[1] It found itself with men from RCA, from Victor, from General Electric and from Westinghouse. It was overstaffed, in a depression, and entering

[1] In gathering material for this article, the Editors asked E. T. Dickey (one of the original City College men) how much floor space there was at the Victor plant. His reply was "If you walk through all the floors of all the buildings, you get damn tired."

higher frequencies than had previously been employed. The diversity receiving system was subsequently adopted as standard at all RCA transoceanic radiotelegraph stations, and the same principles extended to include telephonic operation. The latter makes possible the present standards of the RCA addressed program service, by which programs are received from foreign countries for connection to American broadcasting networks.

Extension of propagation studies into the realm of ultra-short waves, and the development of suitable transmitters and receivers for investigating this new domain led to cooperative program with the Mutual Telephone Company of Honolulu, which gave five islands of Hawaii a telephone system devoid of connecting wires. This was of particularly practical value, since cable connections between the islands had proved unusable because of great ocean depths, and long wave signals had been found to be too mutilated by static. The ultra-short wave system has been in continuous and automatic operation since it was installed, in 1931.



Rube Goldberg in Radio

Today's organized research is not without its ingenious short-cuts. It will be recalled that Edison, as a telegrapher, contrived a combination of clock and automatic telegraphic keying device which "reported" for him to a dispatcher at regular intervals, leaving his mind free for experimental work.

One of today's counterparts is a young engineer at the Riverhead station, whose assignment was to study the angle of arrival of short wave signals. A transmitter attached to a captive balloon was employed in the tests, but it was soon found that any appreciable degree of wind caused the balloon to "bounce," thereby rendering worthless measurements at a given length of cord. Tiring of rising during the best sleeping hours of the night and driving to "location" only to find a defeating breeze, this engineer devised a pendulum with a five-gallon oil can suspended on a ten-foot string. A spike fastened to the bottom of the can was utilized as one contact, and a ring of metal, in the center of which it normally rested, was the other. Wind from any direction would sway the can and close the circuit.

In operation, the complete rig worked like this: On being awakened by his alarm clock, the engineer reached for his telephone and called Riverhead 2576. At the laboratory, the microphone and other apparatus translated the ringing bell into the action of lifting the receiver off the hook for one minute. During this time, contacts of the wind measuring device outdoors actuated a buzzer near the telephone transmitter. By the frequency and duration of the buzzes thus caused, the engineer could determine whether the wind would accommodate his balloon measurements.

Terminal Equipment Division

The function of the Terminal Equipment Division, headed by J. L. Callahan, is to improve the terminal apparatus incident to all phases of central office operation. This includes

Meeting of the Board of Editors, RCA Institutes Technical Press. Front row, left to right: R. S. Burnap, Radiotron; I. F. Byrnes, Radiomarine; Dr. A. N. Goldsmith, Consulting Engineer; C. J. Pannill, Radiomarine and RCAI; L. M. Clement, RCA Victor; C. W. Horn, NBC. Standing, C. S. Anderson, Production; E. S. Colling, RCA Review Manager; R. M. Morris, NBC;

This group is now headed by Max Batsel, one of Dr. Goldsmith's men in his original group.

The work of this Division consists of the development and design of apparatus of the following classes:

1. Photophone sound picture reproducers for use in theatres, schools, etc., for both domestic and export fields, and special designs for the Navy.
2. Sound pictures recording systems. This equipment is leased to motion picture producers, both domestic and foreign.
3. Speech input equipment, for sales to broadcasting companies, in both domestic and foreign fields.
4. Sound systems, consisting of public address, sound reinforcing systems, paging systems, etc. Such equipment is for use in theatres, schools, hotels, factories, etc., and, in special designs by the Navy.
5. Test equipment for manufacturers, service organizations, research laboratories, and operating companies, such as broadcasting stations.

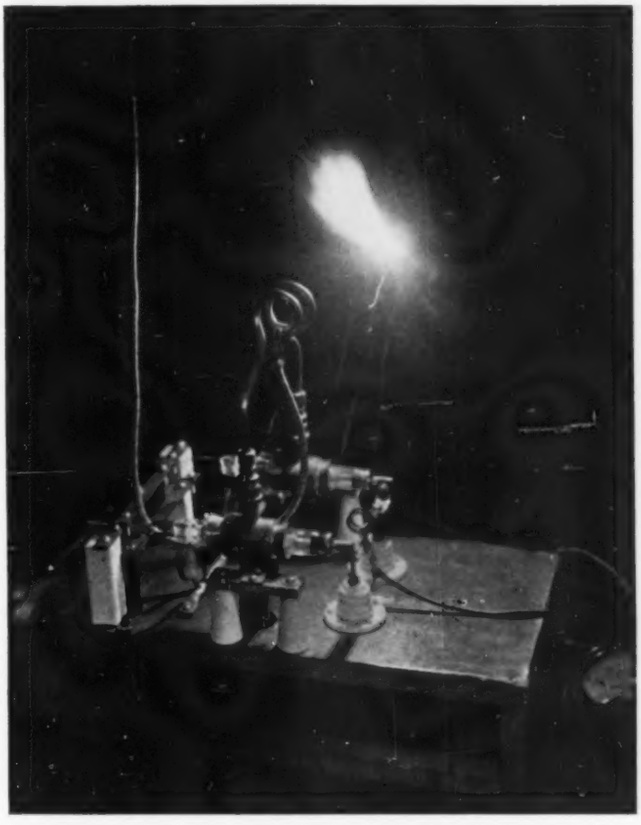
Recent developments of Photophone are the use of ultra-violet recording and the push-pull sound track.

Electronic Research

Very broad indeed is the scope of electronic research. Very broad and widely known, also, are the contributions of V. K. Zworykin. In fact, the basic devices of electronic television and the name of Zworykin are so inseparably linked in technical radio literature that no introduction to his earlier research work is here offered.

Sources of electrons, thermionic emission, photoelectricity, gaseous conduction, electron control, electron optics, electron paths, luminescence—all are studied first from the standpoint of finding new fundamentals and secondly from the standpoint of practical application.

Three projects which are currently receiving much attention in this laboratory section are the secondary emission electron multiplier, the electron image tube and the "Iconoscope." They are not unrelated.



Standing arc drawn from 3.3 meter, 1.5 kw. oscillator, using water cooled 888 tubes. Will operate at 115 centimeters

The secondary emission multiplier is the outcome of research in secondary emission and in electron optics. Although this work has been in progress for only a few years, the multipliers are beginning to be recognized as a commercial possibility. Such tubes are at present in use by astronomers to aid in guiding their telescopes and by others interested in using very low or very high intensities. As development continues, the fields of usefulness of these tubes will increase.

The image tube is another practical use of electron optics. It makes visible images which cannot be seen by the eye except by its use.

General Research

Work along the entire front of the company's activities is carried out by General Research. E. W. Engstrom heads this activity. This Division is no ivory tower of abstract contemplation, as is proved by the mention of two words: Facsimile and Television. The fundamental fields embraced include: radio circuits, and investigations with short waves, radio radiation and propagation, acoustics, physics, recording and reproduction.

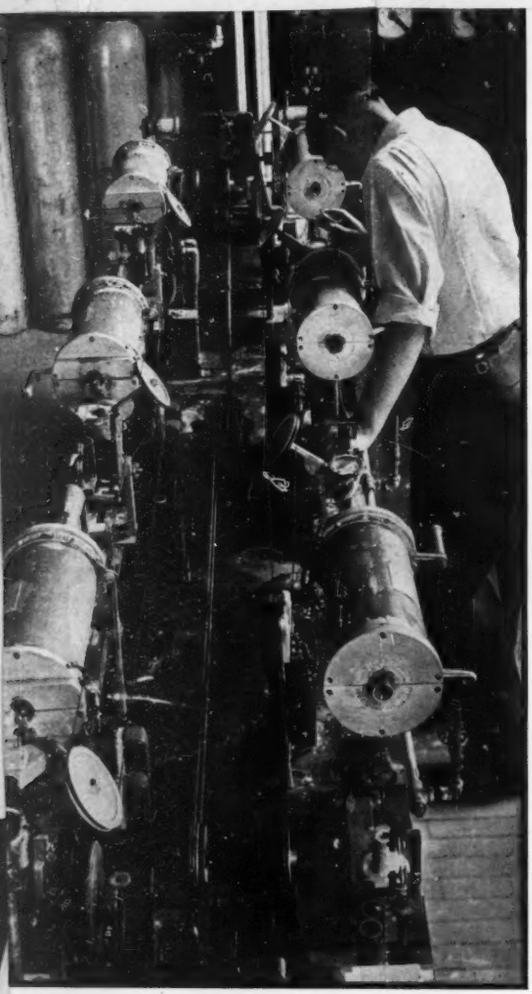
Transmitter antennas, to extend the service range by reducing selective fading, directive antenna structures for ultra-short waves, facsimile, television are but a few of the subjects under constant study.

"V" cut quartz crystals are another development of the laboratories at Camden. These crystals have low temperature coefficients and contribute toward keeping broadcasting and other of the nation's stations on their assigned frequencies.

One of the interesting by-products of General Research is the "automatic snitch" or metal detector used at Alcatraz Penitentiary to detect knives, guns or files concealed on prisoners. There have been produced, also, sources of 60 cycle power very accurately controlled by tuning forks, to provide constant feed drive for facsimile and chronograph devices.

Facsimile

And while on the subject of facsimile; this is a development whose movement so far has been uni-directional. It has become highly successful in transferring news pictures



Coating and baking filament wire at Radiotron plant, Harrison, N. J.

a new field with a luxury item as its immediate mainstay. Plans for expansion into the manufacture of radio equipment for every field of application had to wait.

One of the big problems was to weld one unitary force from these men; to get the RCA Victor idea going. It had to compete with many companies, longer in the set business, smaller and more flexible, none with the technical staff of Victor—and none with the overhead to support.

To shake down this big plant, to hammer out of it a going concern, ultimately producing many products, fell to the lot of W. R. G. Baker who had one additional factor designed to make any chief engineer's hair turn gray—a deep depression. Yet the Victor Division of RCA Manufacturing has not only converted its heritage, a dying phonograph concern, into a successful radio set company, but it supplies other RCA subsidiaries, and the radio industry generally, with research and with products. From the broad point of view Victor is not just a set-making plant. It is a broad-gauge plant making many individual products used very widely in and out of the communication art.

Victor, at Camden, naturally divides itself into certain major divisions. All Engineering, under Lewis M. Clement (who was in Hawaii in 1915 with American Marconi) breaks down into the Receiver Division, Photophone and Test Equipment Division, General Research Division, Electronic Research and Transmitter Engineering.

The Receiver, Transmitter and Photophone Divisions each possess an advance development group, which handles work of an exploratory and experimental nature, with respect to the basic principles of the products of each division.

Receiver Design Division

F. X. Rettenmeyer's Division is responsible for the development and design of all radio receivers, whether quantity production or limited production items, as well as the "systems" work in connection with police and aviation systems—a full time job.

The Advance Development Section of this Division is the "idea factory," producing improvements which are later incorporated in the product. In so far as home receivers are concerned, advanced development is customarily looking one or two years ahead. Circuits and other arrangements now engaging the attention of this group should, in that time, be ready for incorporation into products. Examples of some of the components which have recently come from Camden are magnetite i-f transformers, concentric air trimmers, viscalloid damping of phonograph pick-ups, the "inertia" tone arm, the double voice coil loud speaker, compound horns for theaters, and r-f coils which need no adjustment.

Transmitter Division

The transmitter division, under J. B. Coleman, has five sections. Since transmission is the egg which must invariably precede the chicken of reception, the responsibilities of this Division are a large order.

The first section handles commercial aircraft, police and communications transmitters; the second, special transmitters for Government service; the third, television transmitters; the fourth, transmitters for RCA. Communications and the Radiomarine Corporation of America, and other special equipment such as amateur transmitters, portable equipment and equipment of special designs; the fifth section serves the entire division on standardization and factory contact work.

Photophone Division

Although it entered the sound motion picture field later than other factors serving that industry, Photophone is today in a leading position.

Model showing potential contours in a vacuum tube, Harrison, N. J.

Adjusting intermediate frequency amplifier on an automatic SOS alarm, at Radiomarine

across oceans. It has proved out in other point-to-point applications. And it has even been successfully applied to a service comparable to broadcasting, in sending weather maps to ships at sea, for simultaneous reception. But facsimile service to the home remains the "watched pot" of radio.

Yet, although the saying persists that a watched pot never boils, physicists relegated this notion long ago to the category of old wives superstitions. Facsimile, like many another laboratory development, is on the fire, and will "boil" into home service whenever a complete set-up, in which programs, service and apparatus are integrated into a complete industrial organization.

C. J. Young, of the Camden laboratory, believes in the possibilities of facsimile. Why, otherwise, would he have given the time to developing a facsimile instrument no larger than an average console broadcast receiver, a device which records lettersize pages of type and pictures, and slices completed sheets neatly into a collated stack for the owner to pick out of a tray for his permanent record? Young has other ideas, also, some of which, like the "tick analyser," are already in valuable service. The device mentioned is used by watch manufacturers to make adjustments in a few minutes that might otherwise require days or weeks. Proving that it is not too wise for practical business to wave aside the new gadgets of engineers because customers' names are not on existing lists.

Television is one of the projects which General Research has under its wing. It is an expensive project, but the social possibilities and economic return are very great. Because of the wide scope of the subject, only a brief review can be presented here.

RCA's television project has been in progress for some years. From time to time, laboratory development has been augmented by field tests, that new advances might be tested in a complete system under actual operating conditions. RCA is at present in the midst of such a field test, more ambitious and complete than any previously attempted. From this test it is expected to learn the answers to many problems and to determine the next steps in apparatus, programs and commercial studies.

Television must be approached as a systems problem in which all the components fit accurately. It is essential to establish standards for universal operation and of lasting value. Translated into general terms these standards determine picture detail, picture quality and entertainment value. RCA has been active in the evolution of these considerations and in establishing recommended practice and standards. In the work so far, the research and engineering groups have made practically all the studies and have carried all the burdens from research to commercial planning.

The degree of success of the "shaking down" at RCA Victor may be judged from the fact that this year complete *factory* models (not laboratory models) of all receivers were shown to the trade in May and at the same time carload lots were on the way to distributors. Under the continued program of coordination red tape has been cut, and the required time between an engineer's conception of a receiver model and its final appearance in production has been reduced by a factor of three.

RCA RADIOTRON

Radio would be helpless without tubes. And tubes are the job of the men at Harrison, New Jersey, the Radiotron Division of the Manufacturing Company, headed by J. C. Warner. Tens of millions of tubes are produced here every year.

The Research and Engineering Department, under the management of E. W. Ritter is organized in three divisions. Since the activities of these divisions deal with a common product, their organization is largely on a functional basis. Thus all divisions may be working on different phases of the same problem. For example, this is particularly true of work on television, which represents a major project. The Chemical Research and Engineering Division is working on television in connection with emitters, materials for bulb coatings and materials for cathode ray tube screens; the Electrical Research Division is at present devoting its major effects to investigations of pick-up and reproduction devices for television purposes; the Development and Engineering Division, in its various section activities, is working on transmitting and receiving tubes for television application, cathode ray tubes for pick-up and reproduction purposes and television circuits to accommodate such tubes.

In the following descriptions given under division headings, it should, therefore, be kept in mind that many of the problems are being attacked from different angles by all three groups.

Electrical Research Division

The Electrical Research Section, concerns itself principally with investigation in the field of thermionics. This group is headed by B. J. Thompson, whose personal contributions are frequently described in the technical literature. Electrical research, in this sense, is defined as the search for new kinds of electron devices and the study of the phenomena

involved in these devices. It is not concerned with the *production* (i.e., source) of electrons in a vacuous space, but with the *use* of the electrons.

It has already been stated that this group is concerned with investigating pick-up and reproduction devices for television. It is, in addition, studying high frequency, electronic phenomena, together with basic design principles of tubes for use in short wave transmitting and receiving applications. This latter work is, of course, of importance in the development of television.

Micro wave transmitters, amplifiers and receivers are studied in this group with an eye to the future. The characteristics and uses of electron beams are investigated, the possibilities of gaseous discharge devices are explored and the effects of electron transit time in tubes, together with fluctuation phenomena are studied extensively.

Chemical Research Division

The Chemical Section is organized to carry on investigations in the physical and chemical research fields and to care for those problems naturally referred to them by the engineering departments. G. R. Shaw, who directs this group, has no dull moments.

An important phase of the work of this section is the study of the production of electron emission and of the conditions necessary for its maintenance. This includes the various possible sources of electrons, such as thermionic, photoelectric, impact, gaseous discharges, etc. It also involves study of the materials used for the production of cathodes, such as base metal, carbonates, alkalis, etc., and their processing in tube manufacture.

A continuous study of insulation is carried on, the field of investigation including materials fulfilling the high temperature requirements of heater-cathode insulation, the medium temperature resisting materials for mount supports such as mica and glass, and the low temperature tube components such as bases and basing cements.

Glass, being an important part of the tube, is studied to make it more effective as an insulator and to facilitate its use as an integral part for the support of the other members.

Because of the wide nature of metallic materials entering into tube construction, metallurgy is also important. The metallurgical study of base metals for filaments and cathodes, the metals constituting the grids, anodes, supports, sealing in wire, and even the "getter" is a necessary feature for tube progress.

Development and Engineering Division

This group covers a lot of territory. It is close to the "firing line" of tube usage, and therefore D. F. Schmit, who looks after its manifold functions uses his desk principally for a telephone address. His activities have to do with matters of tube development, application engineering, standardization, and commercial engineering.

The development of new types of receiving, transmitting, photoelectric and cathode-ray tubes is carried on by sections within this group. This is true, not only for tubes for sound broadcast use, but also for tubes for television developmental activities, and tubes for specialized transmitting fields such as aviation, amateur, police, and general commercial service.

Working hand-in-hand with the development group, the application engineering group is concerned with the development of new circuits to employ these new tubes to best advantage. Information gained in this way is supplied as a service to companies engaged in the manufacture of equipment. Through this group, also, special tubes are made available to experimenters and laboratories.

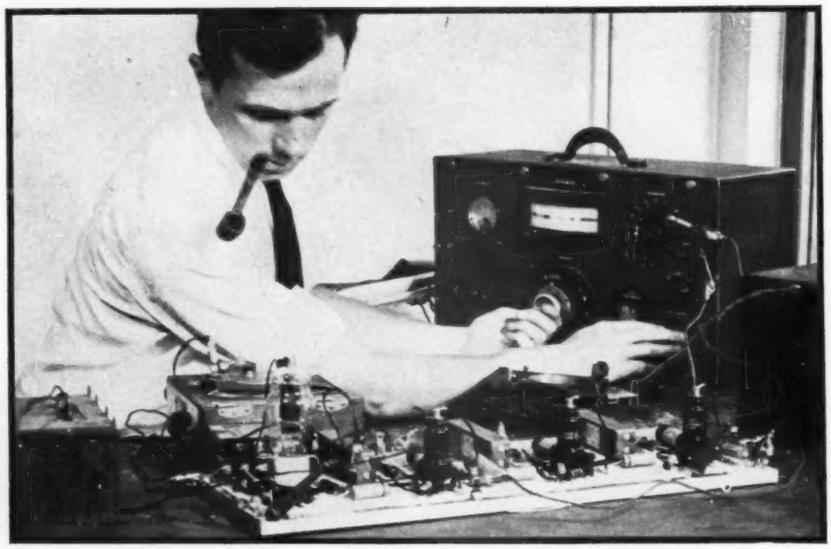
The standardization section has the duty of preparing specifications covering the construction, the processes and the materials used in all radio tubes produced at Harrison. It is also responsible for the design of bulbs and metal shells, bases, and tube cartons.

The commercial engineering section is busied with contact through correspondence and the regular channels of publication and supplies technical information on radio tubes in published form to manufacturers, the trade, amateurs and experimenters, and the public generally. This activity includes the publication of application notes, various manuals on receiving transmitting and cathode ray tubes, and the RCA tube handbooks.

RADIOMARINE

The laboratory facilities of Radiomarine are located at 75 Varick Street, New York. Here various types of marine radio equipment, both receiving and transmitting, are developed for use within the RCA organization and for sale to American shipowners generally. Some of the later developments have included a small direction-finding receiver and loop (*Electronics*, April, 1937, page 9), useful in all manner of small craft, and an Auto Alarm (*Electronics*, April, 1937, page 20), a device for receiving distress signals when the operator is off watch. A distinguishing feature of the Radiomarine Lab set-up is the close contact between the laboratory and the production line, both being located on the same floor, almost within calling distance. In charge of the laboratory is I. F. Byrnes, whose

Checking modulation wave-form of the NBC experimental television transmitter, Empire State Building, New York



Measurements with signal generator at License Laboratory

background includes service with G.E. and RCA Victor, under whose direction the careful design and production necessary in marine equipment has proceeded since 1930.

The problems encountered in the design of marine radio equipment are more severe in certain respects and certainly more changeable than most branches of radio. Apparatus must be made efficient, reliable and as simple as possible. It must be capable of quick installation and be constructed to allow easy and rapid servicing.

Methods of coupling transmitters to antennas must be ingenious as well as practical, since antenna constants vary widely and ordinarily the same "sky-hook" is used for both low and high frequency transmission. Frequency stability is more of a problem than in fixed station transmitters for several reasons; the equipment is subject to vibration and abnormal derises of temperature and must be capable of quick change from calling to working frequency with a minimum error due to human manipulation of dials and controls. Circuit design is influenced by spare parts and spare tube requirements. "Break-in" operation must usually be provided to expedite the handling of traffic.

THE BROADCASTING LABORATORY

The Engineering Department of the National Broadcasting Company has the job of providing facilities for program transmission and of operating them on the high plane of efficiency which modern broadcasting demands. While all of these facilities constitute a "field laboratory" from which much data is obtained during routine operation, strictly speaking, the technical investigations of NBC are carried out in a group of development laboratories, housed in the Radio City plant. The primary function of these development groups is to adapt the engineering advances in other scientific fields to the particular needs of broadcasting, and in so doing to act as a liason officers between NBC and the manufacturing organizations of RCA.

With the rapid growth of broadcasting, the activities of this group have expanded to include the handling of all engineering matters of an experimental nature pertaining to broadcasting, the testing and approval of broadcast equipment, the development of new equipment for special purposes or where suitable equipment is not available, the testing of acoustical and sound isolation materials, the preparation of specifications for acoustic treatment and sound isolation of studios, and the conduct of acoustical absorption, transmission, and vibration measurements, as well as television in its many aspects.

To carry on these activities there are radio, audio, acoustical and television laboratories located in the NBC section of the RCA Building in New York City. R. M. Morris, Development Engineer, is in charge of this group with W. A. R. Brown as assistant. The Development Engineer reports directly to O. B. Hanson, Chief Engineer of NBC.

The most important experimental development in progress at present is television. NBC has been actively engaged in this field for over six years and is now occupied with the technical operating problems of the RCA television field test. Two studios are being operated at Radio City while at the Empire State Building operation of the experimental high power television transmitters associated with the project is carried on. In addition to experimental operation for the RCA field test an operating technique is being developed which will fit smoothly with existing broadcast operational practice when television passes from the experimental stage to regular operation.

An example of operational development is the short wave relay broadcast equipment used extensively in field operations. Since much of this development can be carried out most effectively by the NBC, because it is in intimate contact with the problems involved, the Development Group designs and constructs models of various types of equipment to meet the demands of the Operating Groups. These models are then turned over to the RCA Manufacturing Company where they are produced in quantities sufficient to meet the requirements of all NBC divisions.

Studio acoustics and the related problems of sound transmission and vibration isolation are other phases of broadcasting in which the NBC laboratory is active. Determination of the acoustical absorption coefficients of acoustic treatment materials is made by the reverberation chamber method and the data is applied in the design of studios.

A more complete presentation of the many activities of the NBC Engineering Department, of which the Development Group is only a part, is given in the November, 1936, issue of *Electronics*.

THE RCA LICENSE LABORATORY

The License Division Laboratory was established early in 1930, under the direction of A. F. Van Dyck, in response to a definite need for a centralized technical service to per-

form certain important functions. The activities of this laboratory are determined by the condition that RCA patents are available to about seventy other companies in the radio industry. All these companies are engaged in highly technical businesses, subject to rapid and continual change. For best operation of this complex structure, therefore, it is required that a centralized technical service act as a general coordinating agency, and a "clearing house" in matters of common interest.

The radio industry not only draws upon and uses freely the results of the continuing research and development work of the groups previously described, but utilizes for radio purposes the circuits and devices described by more than five thousand patents owned by RCA, General Electric, Westinghouse, the American Telephone and Telegraph Company and many foreign companies with which RCA has patent license agreements. The RCA patents under which the industry is licensed are increasing at the rate of about 500 annually. Under RCA licenses during the period 1927-1936 there have been produced forty million radio receivers and over half a billion vacuum tubes.

Through the Labo[illegible]ory, information has been trans[illegible]ted to the licensees on the application of patented RCA circuits for such important advances in the art as the superheterodyne, automatic volume control, automatic frequency control, class B amplification, high fidelity receivers, automobile receivers and all-wave reception. Numerous surveys of industry technical practices have been carried out, resulting in valuable information for the guidance of design. Close contact is maintained with the Radio Manufacturers Association, the National Association of Broadcasters, the Institute of Radio Engineers and the Society of Automotive Engineers.

The functions of the laboratory are carried out by several groups. D. E. Foster heads a group which renders engineering assistance to licensees, makes all receiver tests and measurements, conducts industry technical surveys and does field work at licensee receiver plants. S. W. Seeley's group takes charge of tube problems submitted by licensees, field work at licensee tube plants and various special studies of industry-wide importance relating to tubes and sets. E. W. Wilby's group attends to the issuance of patent bulletins, RMA tube standardization, RMA and other committee activities, and general laboratory services such as model shop and maintenance. J. Weinberger carries on economic research relating to the radio industry.

By rendering a consulting engineering service the Laboratory is able to help licensees when they encounter difficulty in the early stages of production of new circuits, parts, etc. The Laboratory can solve such difficulties quickly, because it usually happens that many manufacturers will be introducing a new development at the same time. Finding the solution to the problem of one enables quick service to subsequent inquiries from others.

In the case of certain licensees, every laboratory model of receivers intended for production by them is first submitted to the Laboratory for test and criticism.

Automatic Tuning: The Laboratory's most recent contribution to the industry along these lines, and one which has received widespread usage during the past two years is the development of automatic tuning. This has been introduced by radio manufacturers in various forms, such as "dial tuning", "push button control", and "automatic frequency control." In this instance, a problem arose when "all-wave reception" first made its appearance. Superheterodyne oscillators were required to maintain a higher degree of frequency stability when receiving short waves than had ever before been the case. Starting with devices for compensating oscillator drift through temperature control, the Laboratory's engineers finally were led to various circuit devices for automatic frequency control.

Measurements and Standardization: The Laboratory's measuring equipment serves in some cases as a standard against which calibrations of licensee measuring equipment may be checked, thus insuring uniformity of measurements throughout the industry. Many of the smaller licensees do not have adequate measuring equipment for testing the performance of tubes or receivers and welcome the opportunity for making such tests at the Laboratory.

The work carried on under this heading includes:

(a) The study of technical trends in the industry.

(b) Advance study in the Laboratory of technical factors or new fields having prospective importance to the industry.

The results of these studies are circulated to all licensees in the form of technical bulletins.

These bulletins are supplemented by meetings called by the Laboratory, and attended by engineers of practically all of the licensees, at which discussions of these subjects are held.

At the present time this group is principally concerned with technical studies embracing television, which will lead to the initiation of licensees into the factors of importance in television receiver design.

One of the important continuing activities of the Laboratory is the accumulation and distribution of data relating to the industry-wide characteristics of broadcast receivers. This information is issued annually in the form of a summary of broadcast receiver trends. However, during 1936, an especially comprehensive report was issued, based on the Laboratory's data of the preceding five years, on the subject of "Receiver Characteristics in American Homes." This report was pre-

Ultra short wave antenna at RCA License Laboratory

Portion of License Laboratory where acoustics measurements are made. Lines to NBC studios (16,000 cycles wide) provide high quality material for test (and entertainment) purposes

pared for presentation to the Federal Communications Commission, and forms a set of fundamental data which they may utilize in determining future broadcast allocations.

Standardization Activities

The Laboratory functions as the official agency for tube numbering and standardization of the Radio Manufacturers' Association, as well as for the standardization of related matters such as tube factory test limits. This work was extended recently to include not only standardization of tubes made in the United States, but also those made in Canada, Australia and American type tubes made in Italy. The standard RMA tube data sheets are prepared and issued by the Laboratory.

COORDINATION

All these varied functions of the RCA laboratories, whose field of interest extends to every phase of radio, are coordinated through the central, parent organization, the Radio Corporation of America. Information originating in each of the units flows through the office of R. R. Beal, Supervisor of Research, for distribution to others who may find it useful to their particular problems.

Here, also at RCA, rests the ultimate control of all research activities, as well as the apportionment of appropriations for the various projects. It is a very broad control, which assigns projects to the various laboratory units, thereafter permitting the greatest possible freedom and flexibility of action.

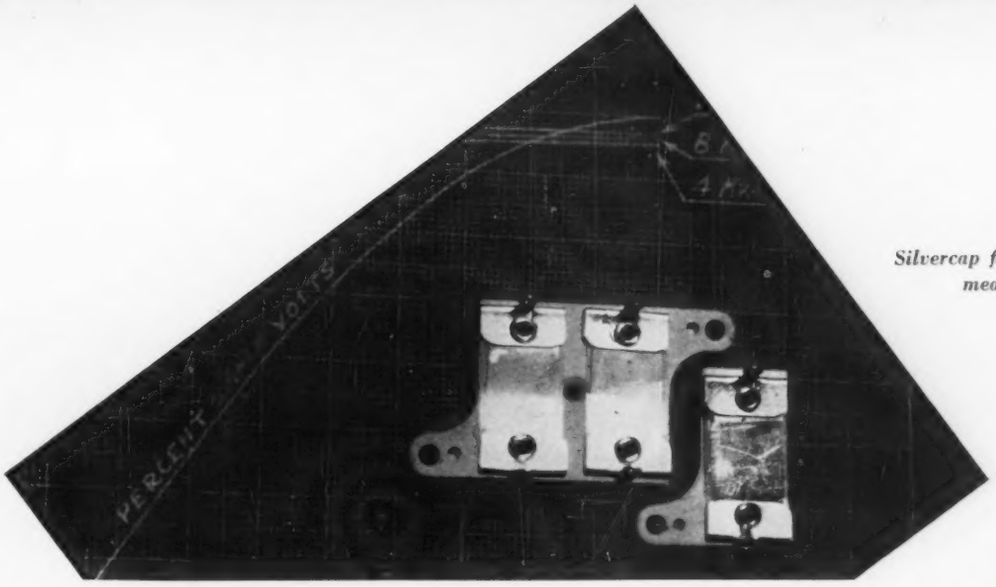
No appraisal of the research activities of RCA would be complete without an acquaintance with the company's guiding hand. Two characteristics distinguish David Sarnoff in his relation to the technical organization of RCA; experience in practical operation and an incisive mind which quickly grasps and evaluates new facts which the specialists in every department of research and development bring to light.

Coming to the new company from American Marconi as Commercial Manager, Mr. Sarnoff had served in every post of the predecessor company. As ship radio operator he knew the importance—and the difficulties—of clearing the hook of messages. All through his career he has been able to gauge what could be done with existing facilities, and what might be done with more effort and investigation directed to this or that end. Always he has appreciated the dimensions of the job ahead, but this has never reduced his impatience at obstacles, natural or otherwise.

At all stages of his career, men came to David Sarnoff's desk wanting to know "the answers." Frequently he could give them out of personal experience. There were many that he could not supply; but every man who went away temporarily unanswered knew that someone would soon be assigned to the job of finding out.

In a recent address before the American Physical Society, David Sarnoff revealed some of the thoughts which enable him to inspire technical groups on to new frontiers. "In our knowledge of the atom," he said, "We first discovered and utilized the negative electron—the outermost and most easily accessible structural element, and the one which, in a sense is nearest to us. Some day we shall know more about and doubtless utilize some of the other elementary nuclear particles which have been discovered in recent years —protons, neutrons, positrons, deuterons and their various combinations. These new discoveries in turn may give us new sources of power, new modes of travel and communication, new manufacturing processes, new forms of illumination, new cures for dreaded diseases, new highways to health."

Research thrives in such an atmosphere.



Silvercap fixed condensers for permeability tuned i.f.'s

Components for 1938 Radio sets

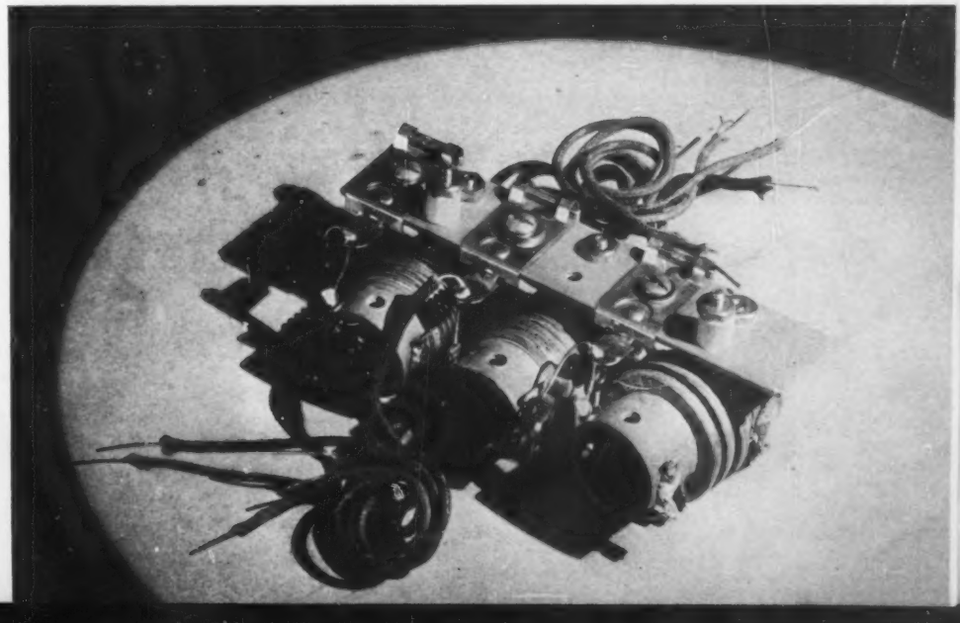
A radio set is no better than its component parts—new items in the components line, presage better engineered if not radically improved receivers for next year

FACED with another year in which sales of radio sets for home and automobile use will set new records, components manufacturers are preparing to play their share in the manufacturing season soon to begin. Early forecasts indicate that 1938 receivers will differ from last year's sets in mechanical details. They will be easier to tune, thanks to some more automatic features and to slanting panels; they may be somewhat better in tone quality but electrical features will probably not differ greatly.

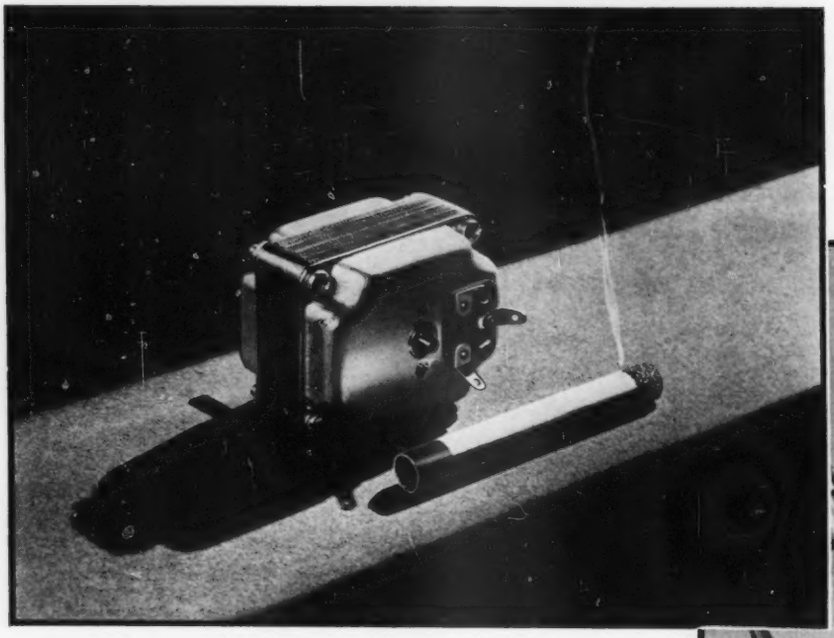
Receiver manufacturers clambering aboard the automatic-tuning wagon have discovered that few parts for these systems are available. Yaxley furnishes several types of mechanical switches—most ingenious devices; Utah has a small motor and several of the old line motor people are developing small motors, but in general the parts people are not inclined to load up with tools on these automatic tuning gadgets until they know whether there will be worth-while sales.

While it is a bit early to give a general survey of what is available for automatic tuning systems, the old "regulation" components have already had their overhauling and are getting ready for the market. In the survey that follows it must not be assumed that only those companies mentioned are developing new material. The season is yet young, and many new products are not yet ready for description.

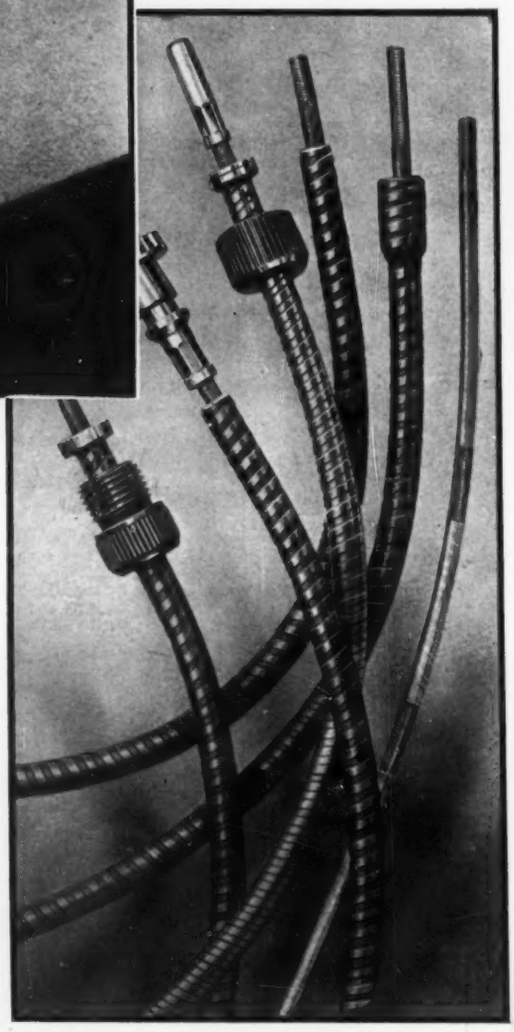
Although 1938 electrolytics will be smaller than any previously used, they will not look must different. Internally, however, there have been changes. A trend toward glass rectifier tubes and away from metal tubes in power supply systems places a responsibility upon the designer of the set and manufacturer of the filter condenser. The rectifier tube must operate satisfactorily in conjunction with the first filter condenser if the set is not to go to the service shop when it is turned on after a long idleness. The change from metal to glass rectifiers will cause demand for the regulating



3-band, 3-gang r-f and i-f Gen-Ral coil-condenser assembly



Shaded pole induction motor (Utah) for remote control and automatic tuning control receivers



Flexible shaft from S.S. White for auto radios

type of condenser which limits the voltage peaks that develop on first turning on a filament-type rectifier. The glass rectifiers will probably be filament types.

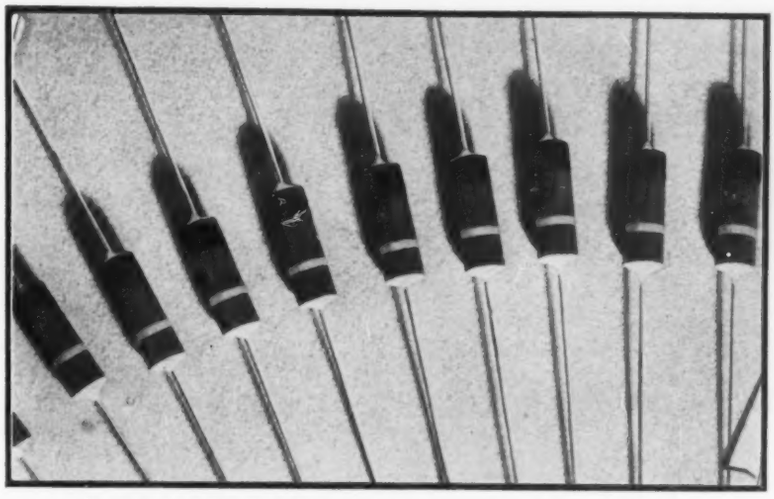
And so the condenser internals have changed. There are new electrolytes, new methods of etching foil, new methods of avoiding leakage. Mallory reports that a chassis submitted by a customer showed a voltage surge of 630 volts although the working voltage was 400. He was supplied with a barrier type of condenser, and avoided a redesign of the chassis. Theoretically surge voltage failure in either wet or dry electrolytic capacitors is caused by the ignition of a minute quantity of mixed gases accumulated at the anode during severe overload, and where scintillation is encountered. If the gases cannot combine, surge voltage failures will not occur. Since one of these gases is generated at the anode side, and the other at the cathode side of the electrolyte, the use of a special high density material, as part of the separator, acts as a barrier and retards their mixture. Compared to other types of separator material, capacitors having non-fibrous cellulose separators will have a much longer life even though repeatedly subjected to overloads high enough to cause scintillation.

The decreased size is demonstrated by the Solar units photographed. Both have the same capacity but the smaller unit is of recent design. These are wet electrolytics; in a can 1 inch by 1⅛ inch, 8 microfarads to be operated at 500 volts can be packed; or 38 microfarads for 100-volt operation. Temperatures as low as —20 deg. Centigrade do not put this new type out of commission. A new formation process reduces leakage to the point where excess leakage is not encountered when voltage is reapplied after a long idle period.

An interesting Mallory condenser is a unit specially designed for reducing intercircuit coupling in auto radio chasses. Coupling effects noted in ordinary multiple section capacitors are caused by voltage drop in the cathode foil and an improper sequence of the anode plates. In fact, the entire matter is due mainly to mechanical rather than electrical design. The voltage drop in the cathode was corrected by the proper placing of the cathode tabs. Each tab was assured positive contact to the container by a special rivet. The plate sequence was arranged after careful analysis of the circuit. A much improved r-f impedance characteristic was obtained through the proper relation between cathode and anode tabs.

The method of connecting the cathode to the container eleminates coupling difficulties. Vibrator hash is at a minimum as the first filter section has an extremely low r-f

impedance at from 10 to 20 megacycles, which is the region of vibrator electrical noise. An actual saving of $0.13 per chassis was accomplished over the cost of the two separate capacitors originally specified. In addition a paper by-pass capacitor was eliminated and the chassis assembly cost reduced.



Popular are the ceramic sealed compact resistors. These particular units are made by Erie

This capacitor is not a stock item. It is, however, of standard construction and was designed by Mallory engineers based on circuit information supplied by the customer.

Although high humidity and high temperatures encountered in many applications compel the condenser to be sealed against moisture, as by aluminum cans, Mallory engineers have developed a cheaper construction by varnishing a paper specially selected for the job. High temperature sealing wax is used at the ends; paint will stick on the outside of the varnished surfaces.

Small-Size Parts

Small size is noted in the controls to be used this year. Volume controls not much larger than a wrist watch are common. Just why the set manufacturers demand such small items is not exactly clear, except for small sets. But they *must* be small and they must also be versatile. Special controls for special purposes are the vogue—and 1938 looks like a year of special purposes.

For the very small sets, loudspeakers must of course be small. This is not new nor is it a trend. Fortunately it looks as though the average radio set will bring close to $100 this year which is a considerable mark-up from last year's average price. Part of this is due to increased costs of sets due to greater labor and material costs—but it is also true that customers are looking at and buying bigger and better sets. They know the little fellows are small in tone as well as small in size.

The really new thing in speakers, too new for the early 1938 sets in fact, is the line of speaker enclosures which Jensen will market. These boxes tightly enclose the loud speaker and have apertures which are closely related to the dimensions of speaker. Both act to enhance the overall performance. When such speaker systems will arrive in home sets is a question—but the trend points this way.

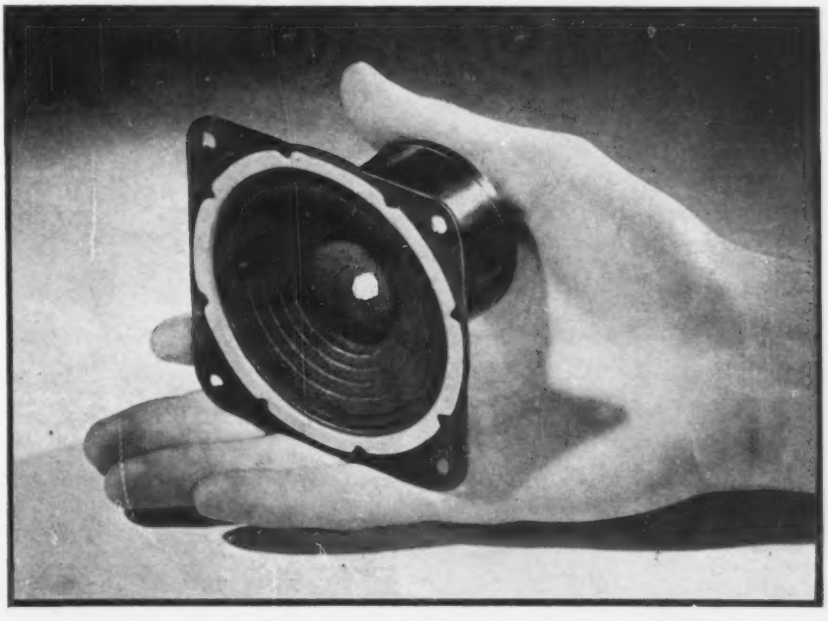
Resistors

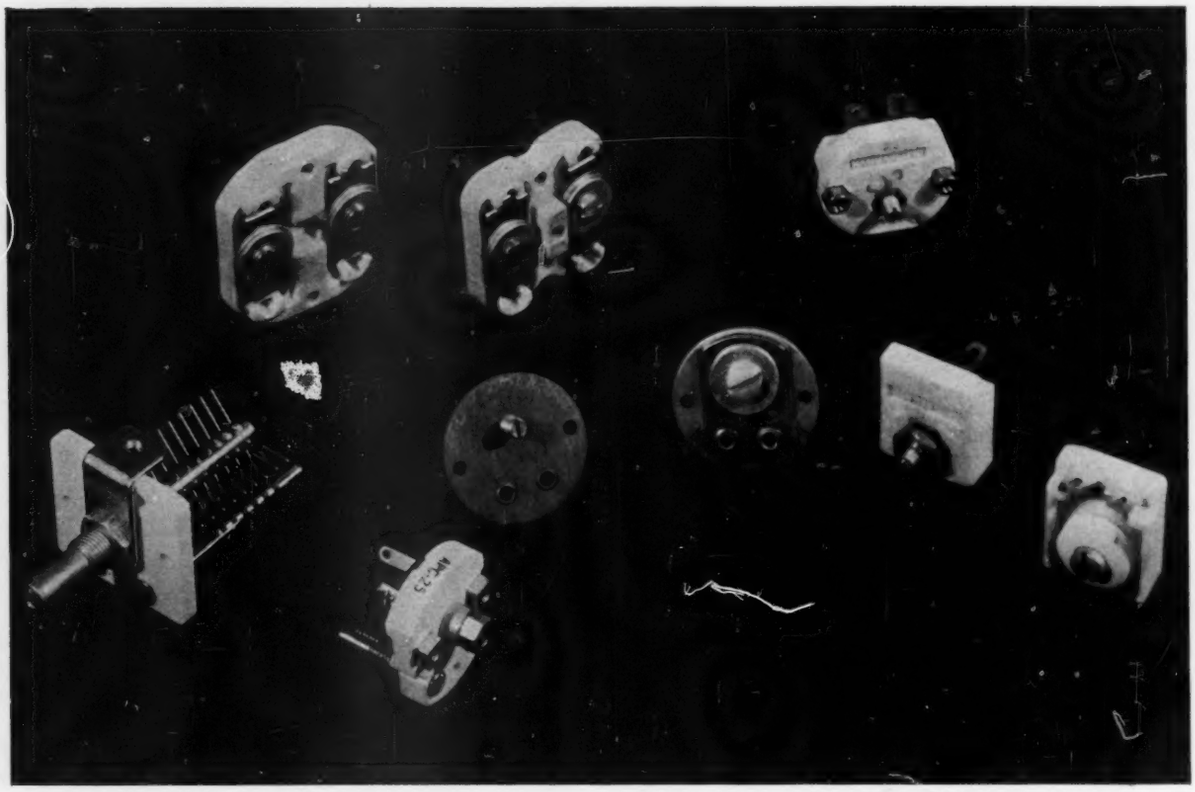
It would take a very large adding machine to sum up the total number of resistors that have gone into home and auto radios during the past five years. Say ten resistors per set, say 8 million sets for 1938. Punch two keys and you get 80 million resistors for the year. Carbon resistors, metallized resistors, wire wound—all have gone through a continued evolution. Fixed resistors, variables—these two have made constant changes toward greater stability as regards temperature, voltage, humidity, power dissipation, noise. For the following material the Editors are indebted to International Resistance, Speer Carbon, Centralab, Erie, Globar and others.

A trend seems to be pointing directly at insulated fixed resistors. Although only three years old they are now made by four or five manufacturers and in 1938 will probably account for the largest proportion of units for receivers, especially for auto sets. This trend seems to be universal and in considerable proportion.

IRC has augmented, recently, its pioneer insulated line of the metal-

A handful of Oxford speaker. It has a cut-off of 300 cycles so that considerable hum can be left in the power supply

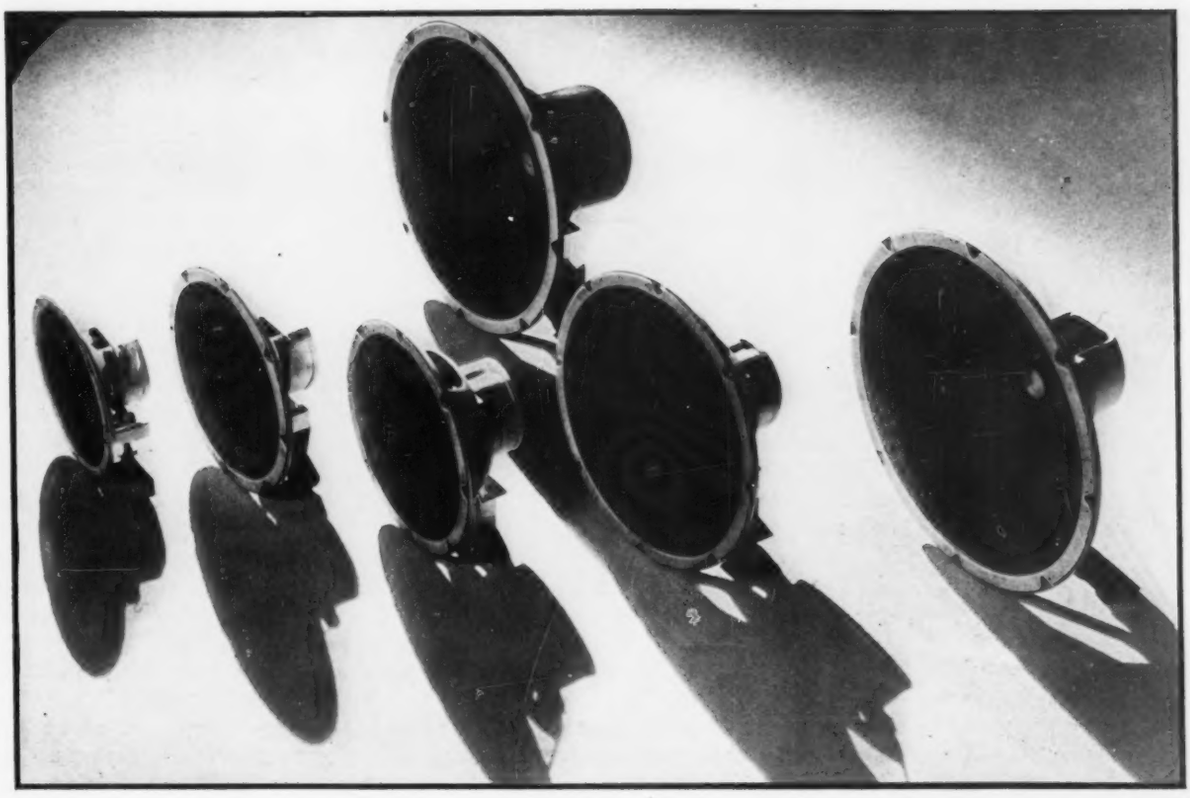




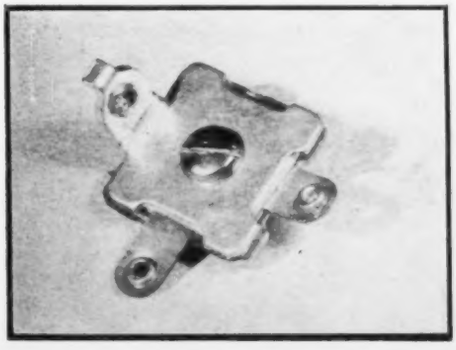
Trimming, padding, tuning condensers of Hammarlund. Note the Isolantite insulation, cadmium plated brass plates

Components are best engineered when good measuring equipment is available. This Tobe Deutschman automatic recorder for speakers or other characteristic measurement has attracted much attention

Q men checking up on components. W. D. Loughlin, H. A. Snow, Boonton Radio with well known Q meter

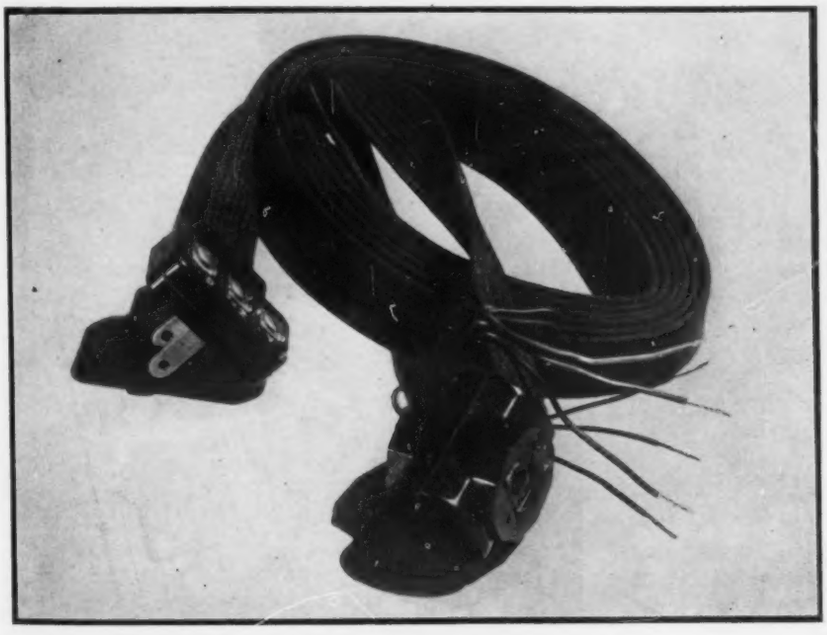


A battery of Rola permanent mag and energized loud speakers



Condenser for i-f systems. Of mica, by Aerovox

All manufacturers are reducing electrolytic sizes. These Solar units have identical capacity and voltage characteristics



For the remote control radio an Alden under-rug cable

lized BT units with a wire wound BW type which has been taking hold very rapidly. It is compact (of the same dimensions as the metallized product) and with wire-wound stability. Ranges to less than one ohm are obtainable. Close tolerances are part of its popularity.

Volume controls of improved design are now available according to IRC engineers. Better stability; lower noise over a long life are the improvements that will appeal to set designers. This new IRC control type CP was developed as a plate circuit tone control, which has required a carrying capacity of about two watts. To achieve this in a small size, a copper plate stamping was used underneath the metallized element with tabs which are bonded with the tabs of the metal cover. In this way, heat developed in the control is rapidly transferred to the cover and through the area of the cover is of course, dissipated into the surrounding atmosphere and chassis. These units have been bought in considerable quantities by several manufacturers and have been found most useful. The design of variable resistance for volume and other control purposes has shown a most interesting engineering evolution.

Trimming Condensers

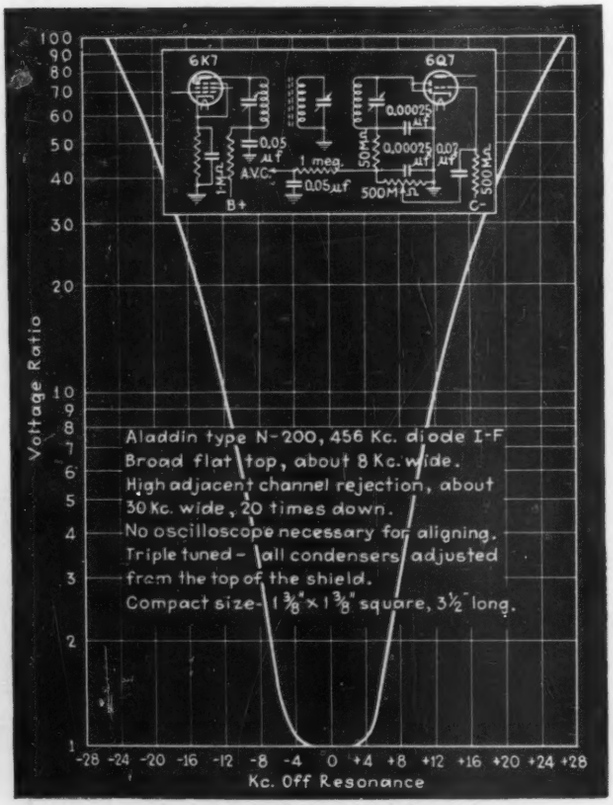
The superheterodyne is highly dependent upon coils and trimming condensers; manufacturers of components have developed new units for the tuning circuits which have most interesting properties. Increased use of permeability tuning of intermediate frequency amplifiers makes it possible to use fixed condensers of very high stability and low loss.

Under the name Silvercap, F. W. Sickles presents a very interesting and new method of installing capacity where it is needed. These are fixed condensers used across i-f coils, permeability tuned. The units are made of high grade mica with a silver deposit on one face of the mica acting as the conducting element. The capacity may be decreased by scraping off some of this deposit. Fixing the silver to the mica makes the capacity of the unit more or less independent of physical strains producing expansion or contraction. The conducting coating retains its position and spacing with respect to the dielectric regardless of bending distortion.

According to Sickles engineers, a heat run on such a condenser produced a change in capacity of less than 0.1 of 1% at 150 deg. F. Under the same conditions a "conventional" condenser showed a change of 10 percent and a permanent set of 5 percent. This condenser had a Q of the order of 4,000 to 5,000. After a humidity run of 24 hours, 100 deg. F., 90 percent humidity, the Q was over 3,000.

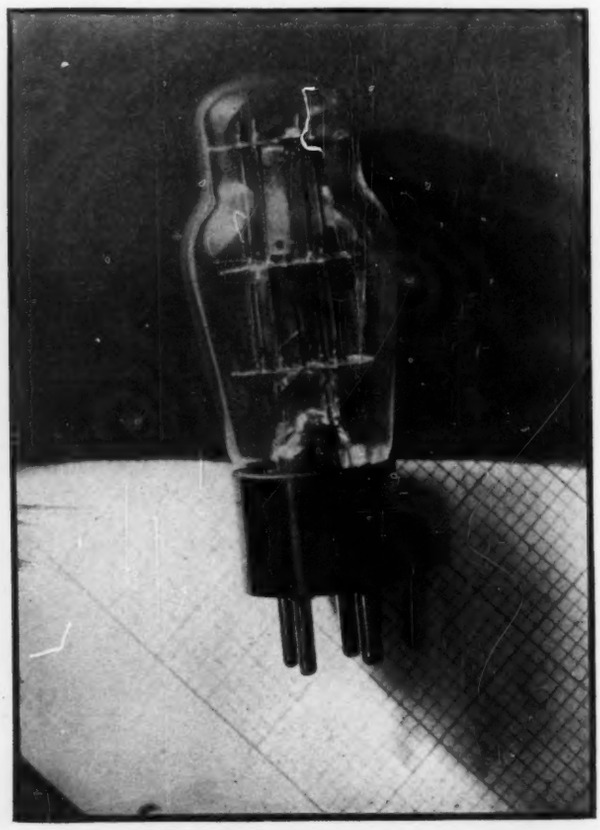
High capacity may be built up in small space. Several types of units are available, depending upon the service they are to perform.

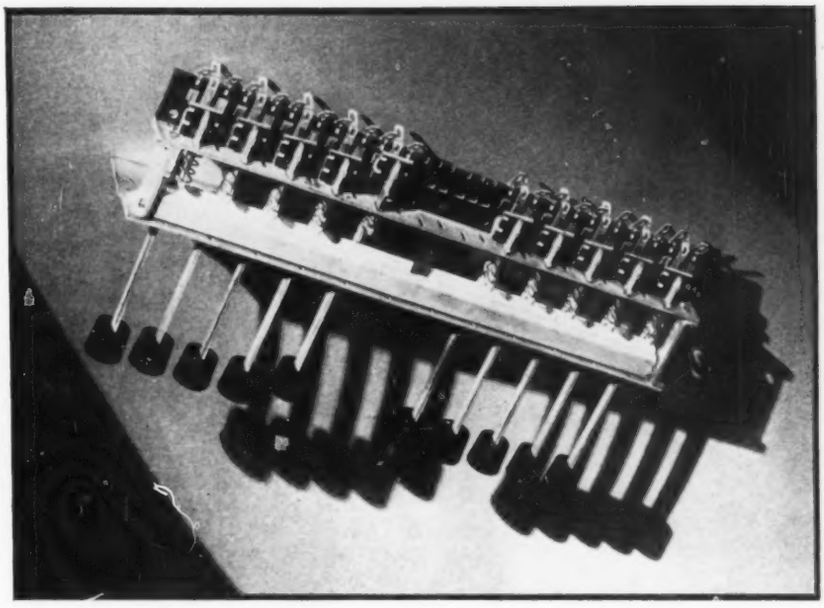
To replace a fixed condenser with a trimmer in parallel, Aerovox has developed an "adjustable" fixed condenser for intermediate-frequency and radio-frequency use. Due to a precise manufacturing design users may specify tolerances as close as plus or minus 1 percent. In use the capacity may be changed by an ad-



Characteristics of i-f transformer of interesting characteristics together with circuit and suggested use

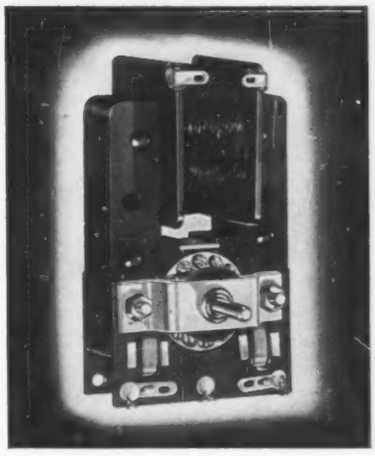
Ballast lamps by Amperite have been life savers for many tubes and components





Push-button tuning comes in this year. This Yaxley unit will handle 10 stations

For 1938 sets, an Alliance motor for tuning



justment screw. Dual units are available. One point about the use of such condensers is the fact that the capacity is concentrated and of low loss, thereby reducing stray capacity from leads, etc.

One of the Hammarlund condensers shown uses a very heavy Isolantite compression washer which provides a low capacity between the rotor plates and ground. The QTD's are used in i-f transformers in AFC circuits. The CTR condenser has double threaded adjustment screws which affords adjustment from either end. Long leakage paths are provided in some units by cut-outs.

Ballasts

Several set manufacturers are offering receivers which may be operated on 6 volts d.c. or on 100 volts a.c. There are also a few operating either from 2 volts or from 6 volts and others are operable from other voltage combinations.

Amperite has made available a new ballast for 2-volt sets. This has better regulation than those heretofore available. For example, a battery variation of from 2.2 to 3.0 volts is reduced to a variation of 1.9 to 2.2 volts. Another new ballast is for a.c.-d.c. sets. By the use of a starting resistor, overloading of pilot lamps is avoided. Instead of applying 110 volts to the set when it is first turned on, only 70 volts is applied. After three or four seconds the starting resistor is cut out by a thermostatic strip and the full line voltage is applied to the receiver. The Amperite regulator in the a.c.-d.c. ballast will keep the tube voltages within plus or minus 5 percent with a line voltage variation of from 95 to 135 volts. The same ballast may be used whether the set used needs 45 or 65 volts for the filaments.

Controls for Auto Radio

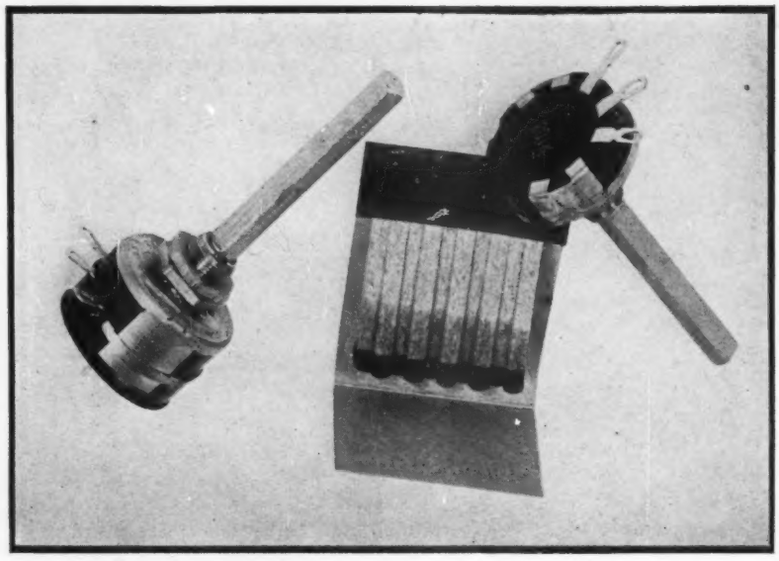
Flexible shafting has been one of the factors that has made automobile radio receiving so popular (estimates are that well over a million new sets will go into cars this year). When it comes to material of this nature, S. S. White Dental Manufacturing Company has established itself very firmly. This company provides set manufacturers with complete shaft and casing combinations with shaft end fittings, casing ferrules and threaded nuts attached—or they supply only shafting and casing in mill lengths or cut to length desired. S. S. White does not make remote control heads or other attachments used with auto radios; for certain manufacturers, however, the company manufactures standard end fittings.

Two sizes of flexible shaft are available, one is of 0.130 inch diameter and the other of 0.150 inch diameter. They have somewhat less torsion deflection than shafts previously made in these sizes. The smaller diameter shaft seems to be the more popular, partly because of the fact that the gear ratio in the average remote control head has increased, which decreases the torque on the flexible shaft.

Both sizes of shafting are supplied in cut lengths with either square or octagonal swaged ends and also with accurately formed square ends so that separate end fittings are unnecessary. Casings for these shaftings are metal and so constructed that they act as a proper guide for the flexible shafting. If too flexible and unable to support its own weight, the casing will impair the efficiency of the shafting—so that the design of the casing is an important part of the flexible shafting business.

Tuning Connectors

For want of a better name, two products of Alden have been described below as "tuning connectors." One is for use with the "magic eye" type of tuning indicator; the other is to connect remote control equipment to the radio sets controlled. One of the tuning indicator tube connectors has an ingenious construction of sunken contacts and a protecting molded shield so that it is impossible to come into contact with the tube prongs when they are inserted into the con-



Small in size, as is the mode, are these controls of Centralab.

nector. This unit was devised to satisfy the Underwriters.

Another unit does not have this protective feature. Both are provided with a one megohm resistor in the connector. It is connected across the contacts or across tube terminals 2 and 4. An integral molding makes the completely insulated pocket for the resistor as well as for each individual contact.

An insulated phenolic disc guides the tube prongs into the connector and snaps into place. The disc can be removed for making instantly available, at one glance, all of the soldering of each contact and the resistor. With the assembly methods used in attaching leads to the contacts used in this connector, and also in the connector for connecting speakers, any inspection of soldering is superfluous.

From the speaker angle, the Alden converter is made in three, four, five, six and seven terminals, held firmly in place by one sheet-metal screw and a lock washer; the leads go directly to the prongs so that they are soldered all in a single operation and the lead wires are completely insulated.

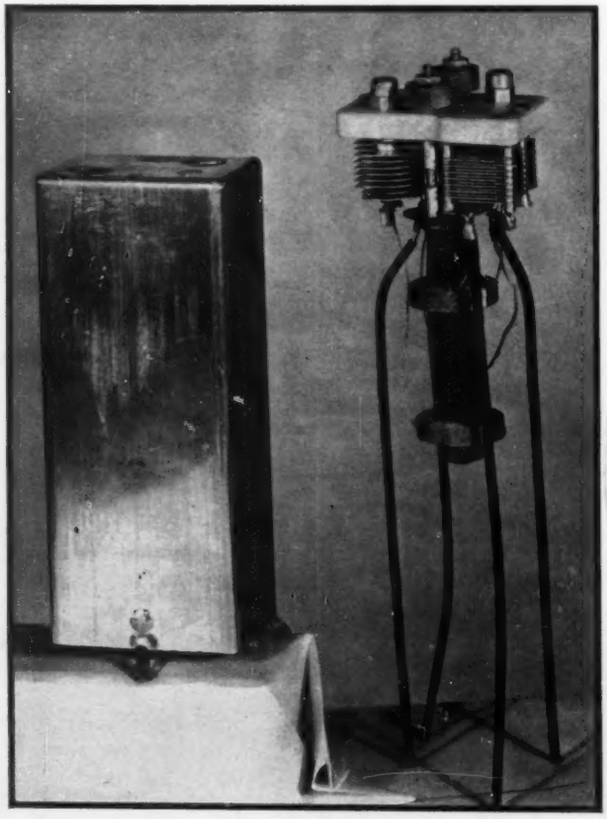
There are no speaker cords dangling from speakers which can in shipment, ruin the diaphragm.

The cables for use with remote control radio receivers are made up in 4- and 5-wire types. These connectors act for arm-chair models as an a.c. power supply, a ground connection, spaced apart from either of which is a single antenna lead or two leads for use with a doublet.

Other Alden cables are for automotive use where trouble in the past has been had with imperfect grounding of shields.

In preparing this early season survey of the new components, the Editors have had the aid of not only those manufacturers whose products are either described or illustrated here, but of others whose new components may not be ready for the market at the present time, or who had merely background data to provide. Among these manufacturers are Ohmite Manufacturing Company, Continental Carbon Company, Sprague Specialties Company, Cornell-Dublier Corporation, Electronic Laboratories, The Muter Company, Globar, Condenser Corporation of America, Hugh H. Eby, General Transformer Corporation, Speer Carbon Company, William Brand & Company, Micamold Radio Corporation.

The cooperation of these manufacturers is hereby acknowledged. There is probably no other industry than radio in which the personnel which supplies the parts and the personnel that uses these parts are so well known to each other. Nor is there any other industry in which changes can come so fast or so completely.



Double tuned air dielectric capacitor. Note the heavy ceramic insulation. A Sickles coil

They took our word

Even before the Western Electric 110A Program Amplifier was officially announced, orders began pouring in from broadcasters. They'd heard what *we* said it would do—and they bought on faith. Now they've been using it for some months—and some of them have written us what it has done for them. Today you need not take *our* word . . .

. . . you can take THEIRS!

WINS: "marked improvement in signal . . . certain dead-spots eliminated . . . both quality and volume improved."

WKBH: "signal at outer edge of service area noticeably improved . . . a great help in maintaining high program level without over modulation."

WOR: "areas where signal was hashed with monkey chatter now cleared considerably . . . 3 db audio increase has definitely aided in clearing this condition."

WTAG: "no difficulty in normal operation at level 3 to 4 db higher than previously used."

WAIM: "a very good investment . . . has increased fidelity of signal."

WDAE: "normal coverage increased 25% . . . quite possible to use 5 db of compression without any particular change in quality of transmission . . . never worry any more about any conceivable sort of line surge."

WISN: "Materially aids in maintaining higher average percentage of modulation . . . signal boosted between 3 and 4 db."

WMBD: "better signal to noise ratio."

KFYR: "average modulation percentage very much higher . . . interruptions due to high audio surges have ceased to exist . . . stations separated 10 KC can be tuned in without monkey chatter."

KXRO: "any station without it can hardly be called modern . . . makes it possible to broadcast most any voice, ballyhoo or shouting without spoiling effect."

WMBH: "unsolicited reports from localities and distances never or rarely heard from before, best prove the 110A is really doing its stuff."

WDAY: "unsolicited reports that we come-in much better . . . average modulation level about 3.5 db higher."

WJBO: "consider the 110A the outstanding development during the past 5 years . . . decided increase in signal . . . practical abolition of monkey chatter."

WHAM: "no fear of distortion from over modulation . . . will raise standards of any station which has one."

KQW: "has improved signal about 100% . . . much favorable comment from listeners and sponsors."

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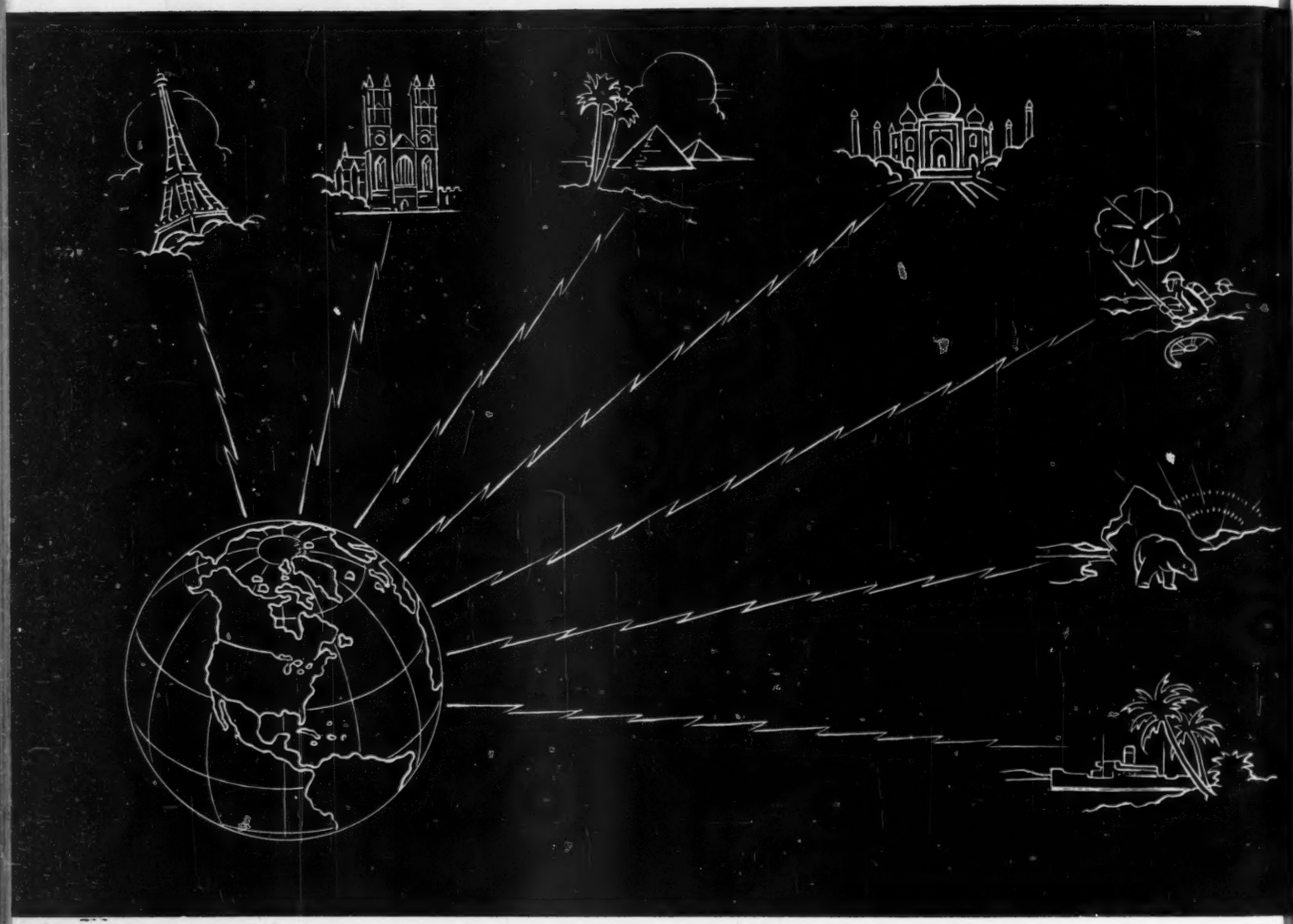
RADIO TELEPHONE BROADCASTING EQUIPMENT

News Across The Seven Seas



TO AND FROM every continent in the world messages are constantly being flashed across the seas via radio telegraph. News . . . business correspondence . . . private messages—all must reach their destination with minimum delay, maximum economy, and accurate transcription.

In commercial radio communication equipment Isolantite* ceramic insulators function with complete reliability...reducing dielectric losses...providing efficient insulation of transmission lines and antennae.

Again, at the receiving end Isolantite's dependable insulating properties provide the highest operating efficiency throughout the entire circuit.

To all branches of the radio communications field Isolantite engineers offer the benefits of their long experience in the manufacture and application of ceramic insulators. If you are planning new installations of radio equipment you will find this experience of great practical value.

** Registered Trade-name for the products of Isolantite Inc.*

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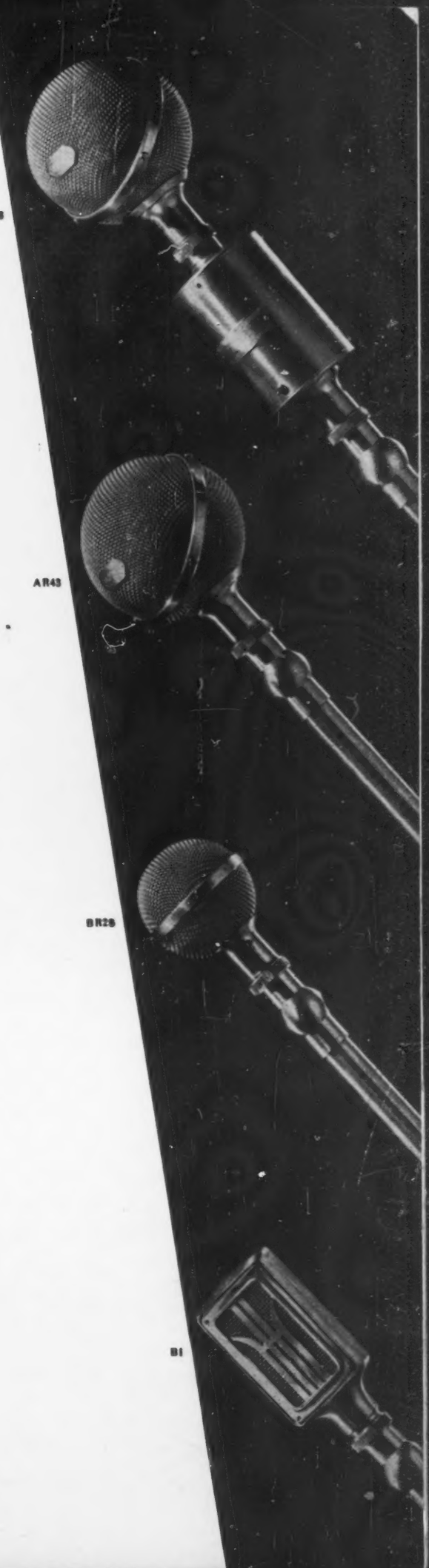

- The most recent contributions by Brush are:

High Fidelity Phono-Pickup with features such as:

Two models, vertical and lateral.
Sapphire point easily replaced.
Low stiffness and low moment of inertia, consequently very light.
Pressure required is under one ounce.
Response — without further compensation — flat from 30 to 10,000 cycles.

High Fidelity Crystal Headphone, Type A-1.

This new Brush headphone is similar in appearance to the standard Type "A," but with high fidelity response.

Other than these two instruments, Brush also announces a general purpose, ultra light weight, metal headphone (Type "B") and at the same price as the present Type "A."

The engineer in search of an accessory for the new personal radio set, will find the Brush "Hushatone" (pillow speaker) an attractive sales feature.

Your microphone problem can be solved by one of Brush's many models, ranging in purpose from public address to laboratory standards. Types B-1 and BR2S, two most popular Brush P.A. microphones, recently reduced from $32.50 to $26.50 and $37.50 to $29.50 respectively.

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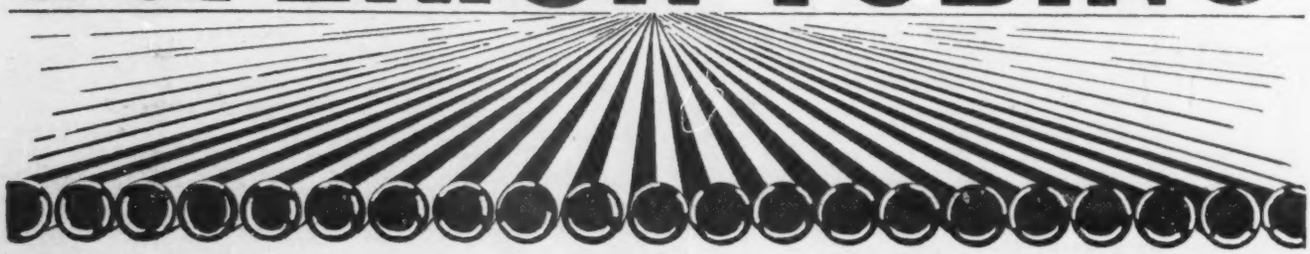
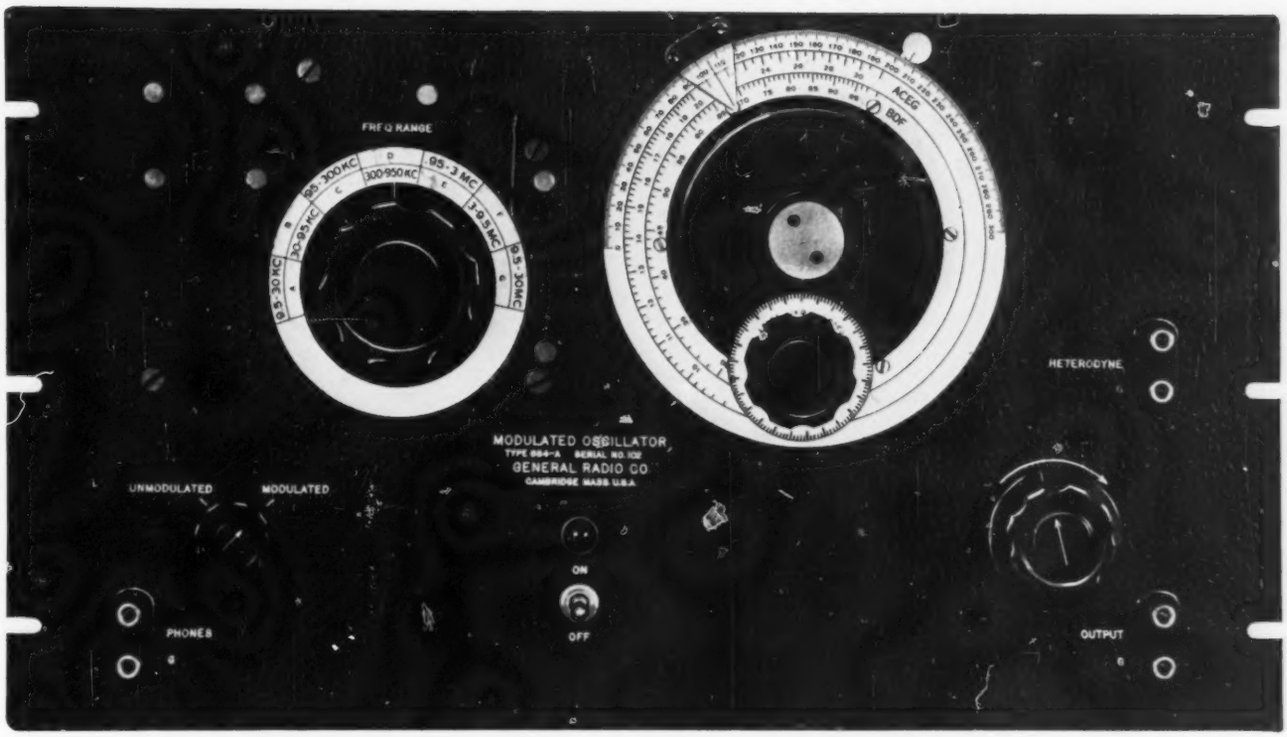
At birth we mapped our own destiny—(1) To make a name for ourselves as specialists in fine small tubing (2) To grow in one direction rather than branch out in many.

Our uniqueness lies in the fact that we have never deviated from these original plans! They are responsible for our gaining many friendly customers who look upon "Superior" as a unique source of supply. . . Superior Tube Company, Norristown, Pennsylvania.

MANUFACTURERS OF SEAMLESS AND LOCK SEAM CATHODE SLEEVES AND SMALL SEAMLESS TUBING IN VARIOUS METALS AND ALLOYS.

SUPERIOR TUBING





NEW MODULATED OSCILLATOR

THIS new G-R general-purpose modulated r-f oscillator fills a long standing need for a source of r-f power covering the entire useful spectrum, with good output and stable frequency. Its advanced electrical and mechanical design includes a number of features which combine to make it an extremely useful laboratory driver with many operating conveniences.

CHECK THESE FEATURES

1. **WIDE FREQUENCY RANGE** — 9.5 kc to 50 Mc. *Direct reading* to 30 Mc — calibration chart 30 to 50 Mc.
2. **OPEN TUNING SCALE** — effective scale-length of *38 feet* between 9.5 kc and 30 Mc!
3. **IMPROVED TUNING CONDENSER** — cast aluminum one-piece frame — ball bearings — *four* spring contracts to rotor.
4. **VERY STABLE OSCILLATOR** — frequency calibration good to 1% — excellent for approximate frequency measurements.
5. **HIGH OUTPUT VOLTAGE** — 25 volts at 100 kc; 30 volts at 1 Mc; 5 volts at 15 Mc; 1.5 volts at 30 Mc.
6. **BUILT-IN VOLTAGE REGULATOR** — regulated power supply insures constant output voltage over normal fluctuations in line voltage.
7. **OUTPUT AMPLIFIER** — isolates oscillator fr[om] utput circuit — effects of modulation and load variations on frequency are negli[gible]
8. **1000-CYCLE INTERNAL MODULATION** — [su]pplied by modulating oscillator — 1000-cycle terminals on panel for a-f testing.
9. **BUILT-IN DETECTOR** — for obtaining heterodyne beats when oscillator is not modulated.
10. **A-C OR D-C POWER SUPPLY** — models available for a-c or battery power supplies. A-C model has built-in voltage regulated power supply.

TYPE 684-A MODULATED OSCILLATOR — A-C Power Supply $340.00
Battery Power Supply $320.00

● WRITE FOR BULLETIN 209 FOR COMPLETE DATA

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SMALLER IN SIZE...only 1¾" long

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SIMPLIFIED CONSTRUCTION

NO SACRIFICE OF ELECTRICAL PERFORMANCE

HIGH SENSITIVITY

LOW INTERELECTRODE CAPACITANCE

LOW LEAKAGE

EASY MOUNTING . . . with either end up so that tube's glass envelope insulates upper terminal

ACTUAL SIZE

RCA's new cartridge-type phototubes are the 921 and 922. Shown here in actual size is RCA 922. A vacuum-type tube, its sensitivity is 20 microamperes per lumen. Interelectrode capacitance —0.6 uuf. The RCA 921 looks the same as the tube shown, is the same size, but is a gas-type tube, with sensitivity of 100 microamperes per lumen—Interelectrode capacitance 1.1 uuf.

OTHER RCA PHOTOTUBES

RCA 868..A gas-type phototube, especially designed for sound-on-film equipment.

RCA 917..A vacuum-type phototube, provides high resistance to leakage currents between electrodes. Excellent for use where high resistance load is desirable to give maximum circuit sensitivity. Offers stable operation, permanent calibration in light-measuring and light-relay devices.

RCA 918..A gas-type phototube, especially designed for use in sound-on-film equipment. The tube has a high-emission cathode which makes it extremely useful at low illumination levels.

RCA 919..A vacuum-type phototube similar to 917, chief difference being terminal arrangement which is reverse of that in 917. 919 can be used in series with 917 to give small leakage current and high over-all sensitivity.

RCA 920..A twin phototube, gas type. Has two separate phototube units in one bulb. Designed primarily for use with double-sound-track film in sound reproduction system having high signal-to-noise ratio.

RCA 923..A gas-type phototube for use in sound-on-film equipment. Except for shorter over-all length, 923 has characteristics similar to those of 918.

Listen to the "Magic Key of RCA" every Sunday, 2 to 3 p. m., E. S. T., on NBC Blue Network.

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FINEST IN TONE

RCA Manufacturing Company, Inc., Camden, New Jersey

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